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A REPORT OF FIFTY-NINE CASES OF SCOLIOSIS TREATED BY THE FUSION OPERATION.*

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In a paper published in the New York Medical Journal, May 27, 1911, entitled "An Operation for Progressive Spinal Deformities," a first report was made of three cases of Pott's disease in which a spinal fusion operation had been done. The title of that paper was carefully chosen because the operation was conceived, as stated in that paper, as being applicable to scoliosis as well as to the kyphotic deformities resulting from tuberculosis. It was not, however, until June 23, 1914, that the procedure was employed in the treatment of scoliosis. This length of time was allowed to pass in order to have unmistakable evidence that the spine of a child could be fused by this operation, and that such fusion would prevent the progress of deformity.

In the period of 1914 to 1919, inclusive, fifty-nine cases of scoliosis were treated by the fusion operation at the New York Orthopaedic Dis-

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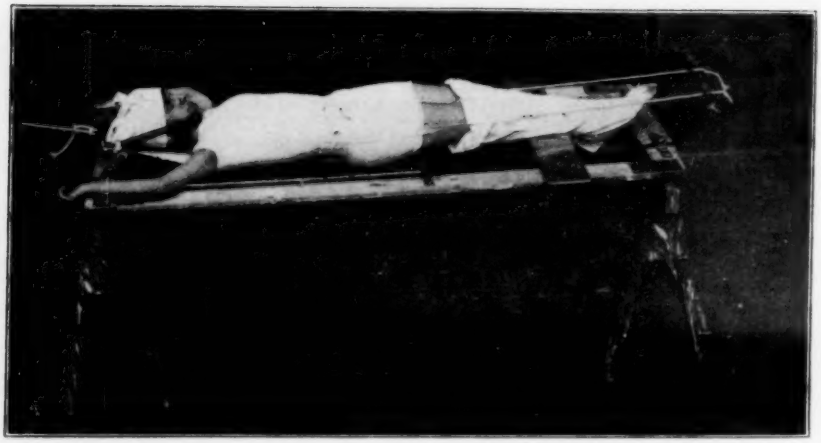

Fig. 1. Patient under traction for application of jacket.

pensary and Hospital. A preliminary report was made of eight of this series on Sept. 8, 1917.† These are included in this report as well, and go to make the total. During the past six months forty-five of these cases have been carefully examined at the hospital and their end-result estimated. In the remaining fourteen cases, while fairly complete records have been made at periods varying from six months to one year since operation, we have not been able to get these patients back to pass on the final result. They have not, therefore, been included in the group of completed records, as the time which had elapsed from the operative date to the period of last observation was not thought long enough to warrant consideration of them as end-results. The forty-five cases have not only been under constant observation since operation, but during the past six months these patients have returned to the hospital and an attempt has been made by every means available (radiograph, photographs, etc.) to judge the end result. The cases were operated on by four different surgeons on the staff.

The period of time which had elapsed since operation in the most recent cases was three and one-half, and in the oldest, nine years; the average being six years and three months. The ages of the patients varied from three to twenty years. All of the patients who did not give a positive history of infantile paralysis showed evidence of having had the disease previously. The lower extremities were involved in twenty-nine of these cases, showing

severe paralysis in twenty and moderate or slight in nine. The abdominal muscles were affected as well in nineteen of the forty-five cases, and eight patients were unable to sit up on account of the trunk involvement. The time elapsed between the attack of infantile paralysis and operation, when definitely known, was from one and one-half to fifteen years. The degree of deformity in the very large percentage of cases was gross, and in all progressive: this in spite of the fact that in all instances treatment by accepted methods, gymnastics, and supports of various kinds, had been carefully carried out.

The first nine cases had very little correction of deformity before operation, while in the remaining cases a very definite attempt was made to correct deformity to the greatest possible degree before operation. The means to this end have been various. Ordinary plaster jackets, Abbott jackets, constant head-pelvic traction by means of a frame designed for that purpose (the patient being kept in bed), and, in some cases, lateral traction as well. It has been interesting to observe how little discomfort was felt by children under a constant force of from 25 to 40 pounds. Finally, however, we have become convinced that the most effective means of correcting deformity is the traction jacket, applied in the recumbent position, changed every two weeks and checked up by radiographs as to the amount of correction obtained. The traction force is applied by the apparatus which is shown in Figure 1, and the amount of force that can be borne without any serious discomfort is very great—from sixty to one hundred pounds. While this method is now adopted, and has been the routine one in use for some time, it was employed in very few cases of this series. We have also found the use of turn-buckle jackets and wedging jackets effective in correcting deformity in lumbar cases, and in some instances we have continued to use turn-buckle jackets after operation. Care must be exercised in the use of these two forms of jackets to prevent pressure sores. When the deformity has been corrected to the greatest degree possible, operation is done.

The operative procedure is as follows: An incision is made through the skin and subcutaneous tissue, from above downward, exposing the tips of the spinous processes of the vertebrae to be fused. The periosteum over the tips of these processes is split longitudinally, and, with a periosteal elevator, pushed to either side, leaving them bare. The periosteum and interspinous ligaments in turn are still farther split and pushed forward a

short distance from each spinous process, as two lateral halves, gauze packs being inserted to prevent oozing. The dissection is carried farther and farther forward upon each vertebra in turn, until the spinous processes, the posterior surfaces of the laminae, and the base of the transverse processes are bared, thereby exposing the ligamentum subflavum attached to the margins of the laminae and the articulations of the lateral processes.

The ligament is removed from the laminae with a curette, and the articulation of the lateral processes is destroyed in order to establish bone contact at this point. With a bone gouge, a substantial piece of bone is elevated from the adjacent edges of each lamina, of half its thickness and of half its width. The free end of the piece from above is turned down to make contact with the lamina below, and the free end of the piece from the lamina below is turned up to make contact with the lamina above. In transposing these pieces of bone from the laminae, it is better to avoid severing their continuity.

Each spinous process is then partially divided with bone forceps and broken down, forcing the tip to come into contact with the bare bone of the vertebra below. The spinous process of the last vertebra below should be turned up to bring about contact with the next above. As the spinous processes of the lumbar region are wide, it is sometimes practicable to split them, turning one half up and the other half down. Thus is established contact of abundant cancellous bone at the articulations of the lateral processes, laminae, and spinous processes. The periosteum and ligament, which together have been pushed to either side and lie practically as an unbroken sheet, are brought together in the middle with interrupted sutures of ten-day chromic catgut. The subcutaneous tissue is then closed with sutures of plain catgut, the skin wound is closed with sutures of silk, and dressings are applied.

The dissection may be made in a practically dry field, without injury to the muscles, if it is subperiosteal and if a free use is made of gauze packs. Only in an operative wound that is free from hemorrhage can the operator see to exercise the care necessary for thorough work. Not only the baring of the bones may be complete, but the periosteum may be separated from them in a practically unbroken sheet and without disturbance of its relation to the surrounding tissues and blood supply. The greatest care should be exercised in the dissection, as by its extent and thoroughness the area of fusion is measured. After the bones are bared, they may be

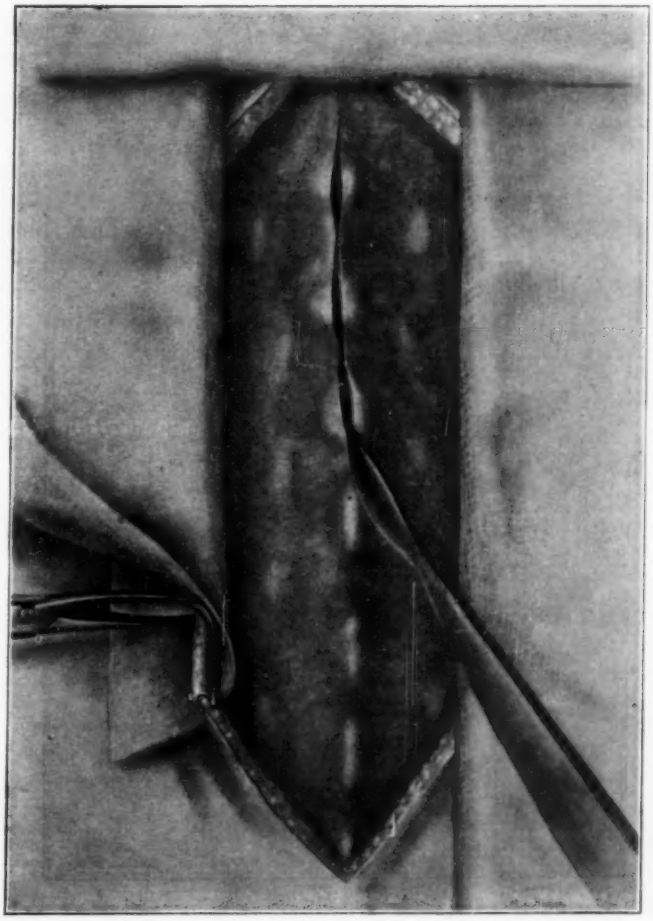

Fig. 2. Skin retracted. Incision being made through ligament exposing tips of spinous processes.

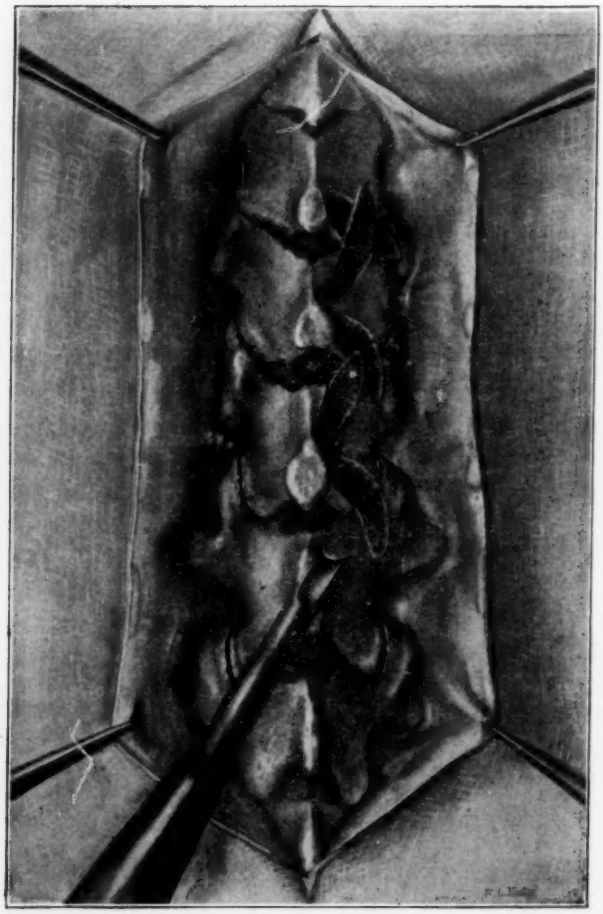

Fig. 3. Periosteum dissected from the spinous processes and laminae, exposing the articulation of the lateral processes and the base of the transverse processes. The ligamentum subflava removed by curet, and the articulations of the lateral processes curetted, and with a bone gouge, pieces of bone are elevated from the laminae.

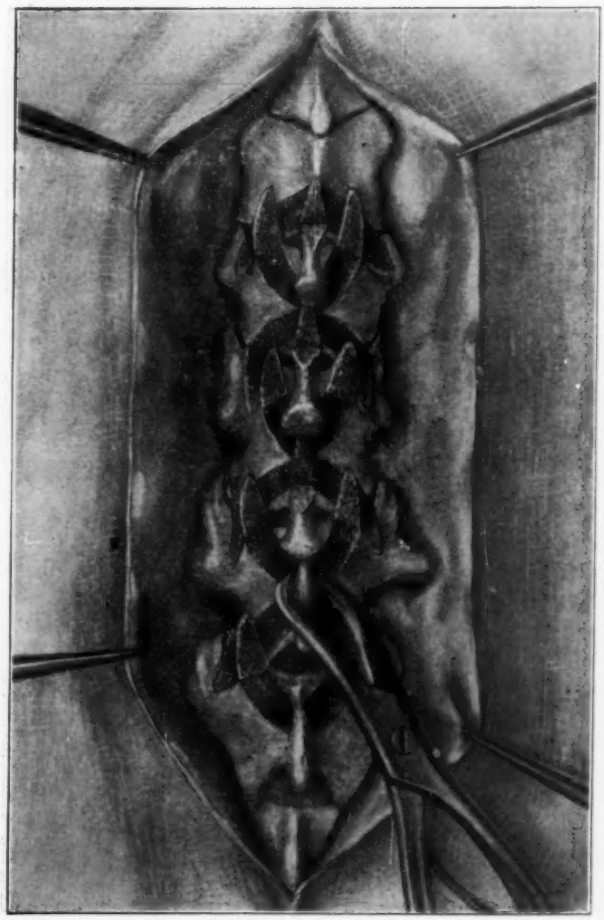

Fig. 4. Bone contact having been secured at the articulation of the lateral processes and of the laminae, with a bone forceps the spinous processes are partially fractured and transposed so as to make contact.

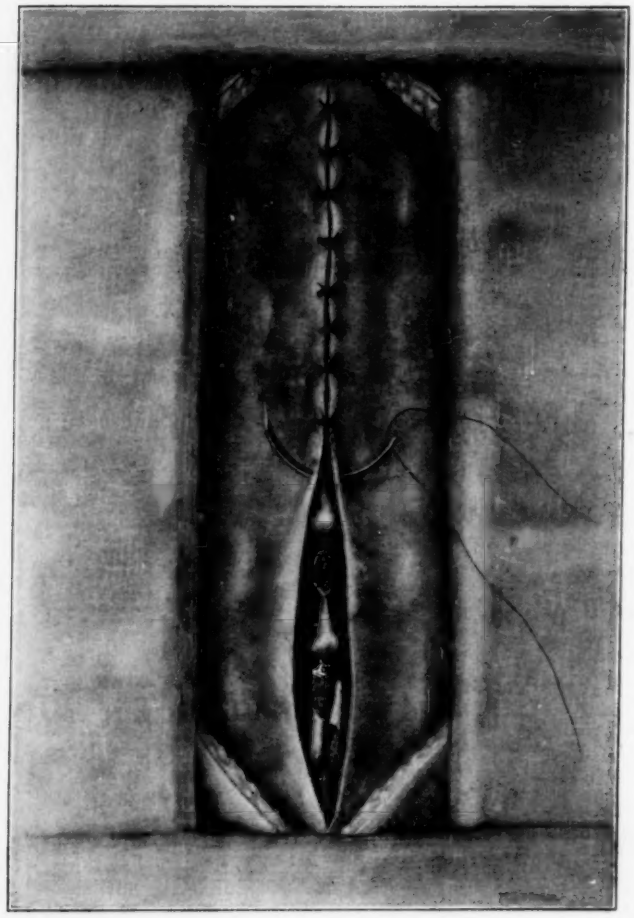

Fig. 5. Periosteum and ligament being closed by interrupted sutures of chromic catgut. After this a subcutaneous suture of plain catgut is used and the skin closed by silk.

treated as indicated above or in any manner which establishes their contact and stimulates bone formation. With the closure of the periosteum, what is practically a tube of periosteum is formed, with its abundant blood supply undisturbed, filled with healthy, living cancellous bone, lying in continuous contact. This situation is entirely consistent with the physiologic laws of bone growth; it furnishes a great stimulus to their operation, and insures a fusion of the lateral processes, the laminae and the spinous processes. The technique appears in Figures 2, 3, 4, 5.

Usually no immediate postoperative support is applied, the patient being placed in a bed without springs. At the end of two weeks, when the wound is healed, the final traction jacket is applied. The greatest amount of correction is, as a rule, obtained at this time, because the deformed area of the spine is temporarily much more mobile from the operative dissection. This jacket is worn for another six weeks, the patient being confined to bed, after which a removable jacket is applied and worn during the day for the next six to twelve months. At the end of this period all support is removed.

The extent of fusion in each case varies with the extent of the curve, and, as a general statement, should extend from the neutral vertebra above to the neutral vertebra below the apex. In the series of 45 cases a cervicodorsal curve was present in 3, a dorsal curve in 17, a dorsolumbar curve in 19, and a dorsosacral, or total, curve in 6 cases. Six vertebrae were fused in 3 cases, seven vertebrae in 5 cases, eight vertebrae in 7 cases, nine vertebrae in 8 cases, ten vertebrae in 7 cases, eleven vertebrae in 5 cases, twelve vertebrae in 6 cases, and fourteen vertebrae in 2 cases; fifteen and sixteen vertebrae were fused in 1 case each. In the last instance, the fusion of the sixteen vertebrae was performed in two operations.

In five of the cases, secondary operations were done to extend the area of fusion, too few vertebrae having been included in the primary operation. In all of these cases the opportunity was taken to expose the previously fused area and in each instance there could be no doubt as to the extent and stability of the fusion which had taken place. One patient had a pseudo-arthrosis at one point in the operative area and had to have a secondary operation. This failure of fusion was obviously due to faulty technique.

In the study of these cases from the point of view of operative mortality, it is interesting to report that there have been, in the whole series of 59 cases, only two deaths, one patient having died of lobar pneumonia four days after operation and the other having succumbed to acidosis the day following operation. The occurrence of shock was rare and never serious.

In six cases of the series of 45, and in one of the 14, natural fusion was found at the time of operation. In one case four vertebrae were fused while three were found fused in three cases and two vertebrae in three cases. This fusion was of the lateral processes at their articulations and of the laminae, and, in one case, of the spinous processes as well. Its occurrence suggests that the principle exercised in the fusion operation is consistent with Nature's own method of arresting the progress of these deformities.

There was one case of infection in the operative wound. All of the others healed by first intention, and in the case of infection there was no interference with fusion.

As a general rule the greatest amount of correction is obtained in the younger patients and in those in whom deformity has existed for shorter periods of time before any secondary bone change has taken place. In other words, the amount of correction of deformity is measured by the degree of mobility of the articulation involved. It is impossible to correct deformity in cases of long standing, where secondary bone change exists, and in which there are areas of natural fusion. Such cases, however, are greatly benefited by fusion, none thus far having been found fused by nature over an area sufficiently long to prevent progress of deformity.. In these at least, any further increase in deformity is prevented, and they are given a less fatiguing posture. Indeed, in all but one of the cases (No. 40) the patients have shown conspicuous relief from fatigue and a very unmistakable improvement in general physical well-being. The removal of jackets and braces, or other forms of support, is an important factor in this particular.

It will be found in a study of these cases that 17.7 per cent. were unable to sit or stand before operation. Posture was very poor in 4.4 per cent., poor in 40 per cent., fair in 31.1 per cent., and fairly good in 6.6 per cent. In the estimation of the end results, 48.8 per cent. were considered excellent, and by this term is meant carriage and posture that are practically normal,

considering the pre-operative condition; correction of the deformity, which is no longer progressive, as well as excellent general health and capacity for physical activity. Good results were obtained in 35.5 per cent. The posture in these cases falls short of being excellent because of a greater degree of paralytic involvement, principally of the abdominal group of muscles, which frequently caused a forward slump. The deformity, however, is stationary in these cases, the patients being in good condition and active. In 8.8 per cent. the result was fair. These patients all have extensive involvement of the lower extremities as well as of the trunk, which impairs their ability to get about and allows body lists of greater or less degree. There were poor results in 6.6 per cent., due to extreme paralysis of the entire musculature, with severe thoracic deformity which could not be corrected and which consequently had an unfavorable effect on the general condition.

In all cases classified as "fair" and "poor" results, there were extensive paralysis and gross deformity of many years duration, and much better results could have been obtained had operation been done earlier. It appears in some instances that the deformity has increased, although it is so complicated that a definite statement to this effect cannot be made. It is also possible that in some there may be a pseudo-arthrosis. Here again a positive statement cannot be made, as the roentgenogram cannot be relied upon to give definite knowledge of whether or not the fusion is complete in even the simplest cases, much less in the complicated ones. The most trustworthy evidence by which to judge of the fact of fusion and of its stability is the arrest of progress of deformity. Errors of judgment were made in some cases in not including a sufficient number of vertebrae in the fusion. However, in estimating the value of the operation, even in such cases, we must compare their results, not with what we hoped for, but with what we knew must happen in the constant progress of deformity and increasing disability inevitable without operation.

In one case (No. 3) with a sharp lumbar curve, bad judgment was exercised in fusing the fifth lumbar vertebra to the sacrum with the pelvis badly tilted. The fusion has held absolutely and there has been no increase in deformity in seven years, although walking, already difficult due to the paralysis, is made more so by a complete elimination of motion between the lumbar spine and the pelvis. The patient works every day, however, and is self-supporting and independent. In one other instance (Case 40)

with a gross deformity and extensive paralysis, there is a definite increase in the deformity and the general condition is not so good as before operation.

The articulation of the fifth lumbar with the sacrum, forming as it does the juncture of the mobile spine with the immobile sacrum, at an angle of from 90 to 140 degrees, is the point of greatest strain in all trunk movement in the normal spine. In cases of dorsal scoliosis with a marked lateral tilt of the fifth lumbar, the susceptibility of this juncture to strain is increased and is very frequently the cause of pain, especially in adult life after ossification of the vertebrae is complete. It would seem wise, therefore, to fuse the fifth lumbar to the sacrum more frequently than has been done in this series of cases, thus transferring the lumbosacral juncture to the articulation of the fifth and fourth lumbar— a more stable articulation. In only three instances in the present series was this suggestion carried out.

SERIES OF FOURTEEN CASES WITH INCOMPLETE RECORDS.

These patients were from two and one-half to thirty years of age at the time of operation, with a duration of deformity of from two to sixteen years. Five had a dorsal curve and nine had a dorsolumbar curve, while all had very marked progressive deformity, two being unable to sit or stand. The lower extremities, as well as the trunk and spinal groups of muscles, were severely involved in five and moderately in three cases. In one case there was paralysis of the feet.

At operation, seven vertebrae were fused in 1 case, eight in 3 cases, nine in 1 case, ten in 1 case, eleven in 3 cases, twelve in 2 cases, thirteen in 1 case and fourteen in 2 cases. Natural fusion was found in one instance (Case 53) where fusion was at the tenth and eleventh dorsal vertebrae, and of the lateral processes, laminae, and spinous processes. This is the only case thus far seen where the spinous processes were fused.

The last examination was made three years after operation in 2 cases, two years after operation in 1 case, one year after operation in 1 case, nine months in 2 cases, seven months in 1 case, six months in 2 cases, five months in 1 case and three months in 2 cases.

Two patients died, one of acidosis twenty-four hours after operation, and one of pneumonia on the fourth day after operation as was noted above.

These are the only deaths which can be considered operative that have occurred in the entire series.

At the time the last note was made, all of the twelve living patients showed better posture. The fusion in each instance seemed to be holding and perfectly solid, without any increase in deformity. While, as has been indicated, these cannot be considered final results, at the same time it seems probable that the results are as good as in the other series.

Photographs are not presented in all of these cases because we were unable to obtain them.

CONCLUSIONS.

1. The study of these cases gives evidence that we have in fusion a means of preventing the progress of deformity of scoliosis in cases in which it is caused by muscle imbalance.
2. That the operation should be done before gross deformity has developed, it being easier to prevent than to correct deformity.
3. That after fusion the upright posture is maintained with greater ease and trunk movement exercised with less fatigue.

CASE REPORTS.

CASE 1 (2193).—H. H., a boy, aged 5½ years at operation, had infantile paralysis 4½ years previously. There was extensive involvement of the lower extremities, the abdominal and spinal musculatures, with a very marked dorsolumbar curve to the left, which included the pelvis. He was unable to sit up. Previous treatment of the curvature had been by jackets, with deformity progressive. Fusion operations were done June 23, 1914, and August 16, 1918, from the tenth dorsal to the first sacral inclusive. Post-operative treatment consisted of jackets after the first, and traction for 6 weeks after the second operation. Result, 8½ years after the first operation, and 4½ years after the second: Fusion firm, deformity not progressive. He can now sit up and stand with comparative ease.

CASE 2 (9296).—J. K., a girl, aged 14 years at operation, had an attack of infantile paralysis 4 years previously. Both legs were extensively involved and there was conspicuous deformity of the spine, showing a marked, sweeping dorsolumbar curve to the right, with severe rotation. She was unable to sit up or walk. Previous treatment of the curvature had been by jackets, with deformity progressive. She had no pre-operative treatment except a double fasciotomy of thigh flexors. Fusion was performed November 3, 1915, extending from the eleventh dorsal to the fourth lumbar inclusive. Six years after operation the deformity had not progressed in the area of fusion, but, owing to

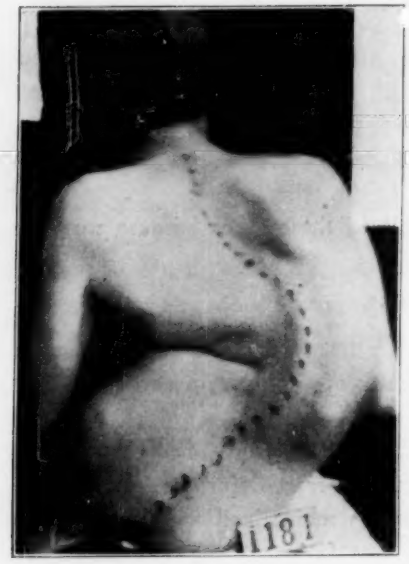

Fig. 6 (Case 2.) Condition before operation.

Fig. 7 (Case 2.) Condition seven years after first, seven months after second operation.

the length of the curve, a second operation was performed April 18, 1922, the fusion being carried upward to the third dorsal. Result, 7 years after the first operation, and 7 months after the second: Fusion is holding. She has much improved sitting and standing posture, can sit up without support and is able to walk in leg braces. Fig. 6 shows her condition before operation; Fig. 7 shows sitting posture 7 years after the first operation and 7 months after the second operation.

CASE 3 (8374).—C. R., a boy, aged 12 years at operation. He had an attack of infantile paralysis 6 years previously, with resulting involvement of the lower extremities and spinal muscles. There was a marked, sweeping dorsolumbar curve to the right, which included the pelvis. He received treatment by jackets but the deformity was progressive. Fusion, January 1, 1916, extended from the ninth dorsal to the first sacral vertebra inclusive. He wore removable jackets after operation. Result, 7 years after operation: Fusion solid, with deformity between the trunk and pelvis remaining, lifting the left foot 3 inches off the floor when standing erect.

CASE 4 (17595).—E. L., a girl, aged 17 years at operation. She had an attack of infantile paralysis five years previously, with extensive involvement of the right lower extremity, the abdominal and spinal muscles, and a marked left dorsolumbar curve with severe rotation

and thoracic deformity. She had had no previous treatment of the curvature, and the deformity was progressive. Mar. 31, 1916, a fusion operation was done from the first to the seventh dorsal vertebra inclusive. Result, seven years after operation: Fusion is firm and the deformity has not progressed. A compensatory curve in the lumbar region tilts the pelvis slightly. Posture is only fair, due to the involvement of the abdominal muscles and those of the right lower extremity.

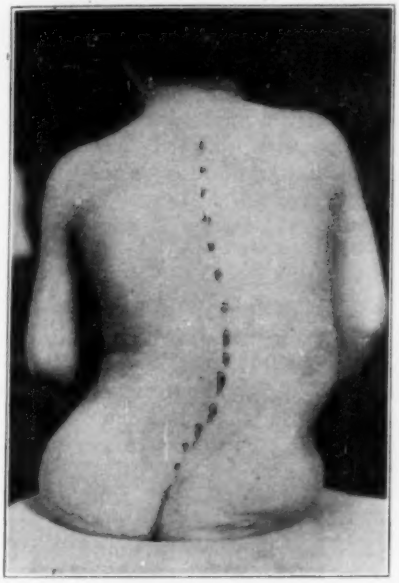

Fig. 8. (Case 5.) Condition before operation.

Fig. 9. (Case 5.) Condition six and one half years after operation.

CASE 5 (7379).—W. D., a boy, aged 5 years at operation, had infantile paralysis two years and nine months previously. There was marked involvement of the lower extremities and of the abdominal and spinal muscles, with a long sweeping dorsolumbar curve to the right. A fasciotomy was done to correct the leg deformities, and the curvature was treated by jackets. The deformity was progressive, and May 19, 1916, a fusion operation was done, extending from the eighth dorsal to the third lumbar vertebra inclusive. A Knight corset was worn after operation. Result, six and one-half years after operation: Posture is good, but a posterior curve has appeared, and there is a question of pseudo-arthrosis at the junction of the middle and lower thirds of the fused area. Fig. 8, before operation; Fig. 9 shows the posture six and one-half years after operation.

CASE 6 (2369).—S. S., a boy, aged 5 years at operation, had an attack of infantile paralysis four years previously. His general condition was poor and there was very extensive paralysis of the upper and lower extremities and of the abdominal and spinal muscles, permitting a marked anterior and right lateral dorsolumbar curve. He was unable to sit up. The leg deformities were corrected, and July 6, 1916, a spine fusion was done from the sixth dorsal to the third lumbar vertebra inclusive. He wore a Knight corset after operation. Result, six and one-half years after operation: Deformity has progressed slightly below the fused area but he is able to sit up without support. The fused area is solid but the general condition continues poor.

CASE 7 (13275).—F. D., a boy, aged 9 years at operation, had infantile paralysis four years previously, which left fairly extensive involvement of the lower extremities and spinal muscles with a moderate right dorsolumbar curve. His general condition was good, but the deformity was progressive, and July 18, 1916, a spine fusion was done extending from the seventh dorsal to the fourth lumbar vertebra inclusive. Post-operative treatment consisted of jackets and exercises. Result, six and one-half years after operation: Fusion is firm. There is a slight increase in the curve, but the posture and general health are excellent.

CASE 8 (15877).—J. D., a boy, aged 16 years at operation, had infantile paralysis fifteen years previously. His general condition was fair, but there was complete paralysis of one leg, with involvement of the spinal musculature, permitting a marked left dorsolumbar curve with rotation and resulting inability to sit. He had had no previous treatment and the deformity was progressive. Fusion was performed Dec. 13, 1916, extending from the tenth dorsal to the third lumbar vertebra inclusive. Post-operative treatment by jacket and corset. Result, six and one-half years after operation: Fusion is solid. There is no increase in the deformity and he has excellent posture and health.

CASE 9 (11167).—W. B., a boy, aged 15 years at operation. Had infantile paralysis thirteen years previously which left moderate involvement of the lower extremities and extensive involvement of the spinal musculature. There was a marked right dorsolumbar curve with rotation of equal degree. He was treated by exercises, but the deformity was progressive, and Dec. 29, 1916, fusion was performed from the eighth dorsal to the third lumbar vertebra inclusive. He wore a brace after operation. Result, six years after operation: Fusion is solid and the deformity has not progressed. He now has excellent carriage and posture considering the degree of deformity. Figure 10 shows the condition before operation; Figure 11, six years after operation.

CASE 10 (722).—A. F., a boy, aged 9 years at operation, had an attack of infantile paralysis seven and one-half years previously, moderately involving the lower extremities and spine, permitting a moderate right dorsolumbar curve with deformity progressive. He had no previous treatment of the curvature and the spine was fused Aug. 21, 1917, from the fifth dorsal to the eleventh dorsal vertebra inclusive. Result,

Fig. 10. (Case 9.) Condition before operation.

Fig. 11. (Case 9.) Condition six years after operation.

five and one-half years after operation: The fused area is solid but the deformity has increased because the fusion was short at the lower end. In spite of this he has very good carriage and is in good general health.

CASE 11 (7692).—E. K., a boy, aged 9 years at operation, had an attack of infantile paralysis five years previously, which left a very extensive paralysis of the upper and lower extremities, the abdominal and spinal muscles. He was unable to sit up. There was a marked, sweeping, dorsolumbar curve with severe thoracic deformity. Previous treatment: braces and a double fasciotomy. Fusion was done Aug. 21, 1917, from the seventh dorsal to the first lumbar vertebra inclusive. After operation he wore a Knight corset. Result, five and one-half years after operation: The fused area is solid but is not long enough, and to this is due the slight increase in deformity. He is able to sit up, however, and can stand with the aid of leg braces. His general condition is only fair.

CASE 12 (17402).—C. F. E., a girl, aged 4½ years at operation, gave no history of infantile paralysis. She was under observation for one year, however, preceding operation. There was a slight left curve, in the upper dorsal region. She received treatment by spinal uprights and braces, but the deformity was progressive, and Aug. 27, 1917,

fusion was done from the first to the sixth dorsal vertebra inclusive. After operation she wore a spinal assistant with a head-piece. Result, five and one-half years after operation: Fusion is solid, there is no increase in the deformity, posture is excellent and she is in excellent health.

CASE 13 (18972).—D. J., a girl, aged 14 years at operation. Had infantile paralysis ten and one-half years previously, with extensive paralysis of the right lower extremity and the spinal muscles, permitting a marked left dorsolumbar curve with tilting of the pelvis and considerable thoracic deformity. She received no previous treatment of the curvature and the deformity was progressive. Fusion was performed Aug. 29, 1917, from the eighth dorsal to the second lumbar vertebra inclusive. Postoperative treatment by jackets and Knight corset. Result, five and one-half years after operation: Fusion is solid and the deformity has not progressed, although the pelvic tilt remains the same. Walking function and posture are comparatively good. General condition is excellent.

CASE 14 (9469).—G. R., a boy, aged 3½ years at operation. History of an attack of infantile paralysis could not be obtained, but the patient was under observation for two years before operation. The spinal curvature was present when he was first seen, the spine was in a very relaxed condition, and the deformity progressed during the period of observation in spite of exercises and braces. There was a slight dorsal curve with moderate asymmetry of the chest. Fusion was performed Sept. 26, 1917, from the seventh dorsal to the first lumbar vertebra inclusive. He wore a Knight corset after operation. Result, five years and three months after operation: Fusion is solid and the posture perfect; deformity has not progressed.

CASE 15 (20829).—M. Z., a boy, aged 14 years at operation, had infantile paralysis twelve and one-half years previously, which left severe involvement of the spinal musculature with a marked left dorsal curve and severe thoracic deformity. He received no previous treatment and the deformity was progressive. Nov. 21, 1917, fusion was performed from the seventh cervical to the seventh dorsal vertebra inclusive. He was treated after operation by a brace with a head-piece. Result, five years after operation: Fusion is solid and the deformity has not increased. He has excellent posture and carriage.

CASE 16 (20575).—M. C., a girl, aged 17½ years at operation. No definite history of infantile paralysis was obtained, but the patient stated that she had worn a special corset for three years and had been in a plaster cast for a short period. There was a marked right dorsal curve with considerable rotation. She was treated by plaster and corsets, but the deformity was progressive, and Feb. 15, 1918, fusion was done from the fifth dorsal to the first lumbar vertebra inclusive. Natural fusion was found to have taken place between the laminae of the eleventh and twelfth dorsal and the first lumbar, which accounts for

the difficulty with which correction was made. Traction of the spine was maintained for five weeks, followed by a plaster shell for eight weeks. When last seen, two years after operation, she was in excellent health and had much improved in posture and carriage. The fusion was solid and correction had been obtained.

Fig. 12. (Case 17.) Condition before operation.

Fig. 13. (Case 17.) Condition four years, ten months after operation.

Case 17 (21736).—R. S., a girl, aged 15½ years at operation. Date of attack of infantile paralysis is not known. She exhibited slight involvement of the intrinsic musculature of the feet, and a marked dorsolumbar curve to the right, with considerable thoracic change. The deformity was progressive in spite of pre-operative treatment by exercises, and Mar. 19, 1918, fusion was done from the fifth dorsal to the twelfth dorsal vertebra inclusive. Postoperative treatment consisted of extension and steel uprights. Result, four years and ten months after operation: Fusion is solid, she is in excellent health, and has excellent carriage and posture; the deformity has not increased. Figure 12 shows the condition before operation; Figure 13, four years and ten months after operation.

Case 18 (10904).—E. D., a girl, aged 11½ years at operation, had an attack of infantile paralysis nine and one-half years previously.

slightly involving the lower extremities and markedly affecting the spinal musculature, permitting a long dorsolumbar curve to the left with considerable thoracic deformity. She had pre-operative treatment by exercises and jackets, but the deformity was progressive. Fusion, Apr. 2, 1918, from the second dorsal to the tenth dorsal vertebra inclusive, was followed by traction. The fusion was solid but considered short at the lower end, and Aug. 11, 1920, was continued down to include the third lumbar vertebra. She then had traction followed by removable jackets and exercises. Result, four and one-half years after the first operation and two years and three months after the second: Fusion is solid, with considerable correction in the deformity and no increase since the last operation. Excellent posture and health.

CASE 19 (16340).—C. T., a girl, aged 9½ years at operation, had infantile paralysis one and one-half years previously. There was severe involvement of the lower extremities and of the abdominal and spinal musculatures, permitting a posterior dorsolumbar curve with slight deviation to the right. She was hardly able to sit or stand without support. The deformity was progressive. She was treated by hyperextension before operation, and May 8, 1918, fusion was performed from the eleventh dorsal to the fourth lumbar vertebra inclusive. Postoperatively she was treated by a plaster shell and wore a Knight corset and at a later date had a knee fusion to stabilize the right leg. Result, four and one-half years after operation: Fusion is solid, the deformity is decreased and it has not progressed since fusion. She is able to sit with ease and can stand without spinal support.

CASE 20 (17649).—K. F., a boy, aged 7½ years at operation. Date of attack of infantile paralysis unknown. There was slight involvement of the lower extremities and marked paralysis of the spinal muscles, which left a long sweeping curve to the right, and severe thoracic deformity. The deformity was progressive although he was treated by jackets. Fusion was performed May 14, 1918, from the seventh cervical to the seventh dorsal vertebra inclusive. Postoperative treatment was by traction and exercises. Result: fusion solid with no increase in the deformity.

CASE 21 (16966).—F. F., a girl, aged 14 years at operation, with infantile paralysis twelve years previously, extensively involving the lower extremities and spinal musculature. There was a marked dorsal curve to the right with considerable thoracic deformity; the condition was progressive. She wore jackets before operation. Fusion was performed June 5, 1918, from the third dorsal to the first lumbar vertebra inclusive. Postoperative treatment was by traction. Result, four and one-half years after operation: Fusion is solid. Posture is excellent and the deformity not progressive.

CASE 22 (20086).—M. Z., a girl, aged 14 years at operation. There was no history of infantile paralysis, although she showed a very marked dorsal curve to the right with great thoracic deformity. She was first

treated by jackets, but the deformity was progressive, and July 12, 1918, fusion operation was performed from the seventh cervical to the eleventh dorsal vertebra inclusive. Operation disclosed natural fusion at the apex of the curve. Result, four and one-half years after operation: Fusion is solid, general health is excellent, she has comparatively good posture, and the deformity is not progressive.

CASE 23 (22282).—C. E., a boy, aged 9½ years at operation, had an attack of infantile paralysis seven and one-half years previously, which left moderate involvement of the lower extremities and severe paralysis of the abdominal and spinal musculatures. There was a marked right lateral curve in the dorsal region with exaggerated thoracic deformity. The condition was progressive. He had previous treatment by jackets with head pieces. Fusion was performed July 23, 1918, from the seventh cervical to the eleventh dorsal vertebra inclusive. He was then treated by traction jacket. Nov. 11, 1919, a secondary spine fusion was done extending the fusion to the third lumbar. Treatment by removable jacket and postural exercises. When last seen after the second operation, the postural slump had decreased and the deformity was stationary.

CASE 24 (24161).—M. G., a girl, aged 7 years at operation, had infantile paralysis two and one-half years previously. There was extensive involvement of the lower extremities and of the abdominal and spinal musculatures, permitting a marked right dorsolumbar curve with severe asymmetry of the trunk. She was unable to sit without support. She had no pre-operative treatment of the curvature, but a double fasciotomy of the thigh flexors was done to correct the hip deformity. The spinal condition was progressive, and July 24, 1918, fusion was performed from the sixth dorsal to the second lumbar vertebra inclusive. Result, four and one-half years after operation: Fusion is solid but the fused area is short and the patient is still wearing a removable jacket to prevent slumping. She is able to sit and stand, however, without support except to the extremities.

CASE 25 (26113).—M. C., a girl, aged 20 years at operation. There was no definite history of infantile paralysis, although curvature of the spine had been noticed for five years. The lower extremities were slightly involved and the spine showed a right dorsolumbar curve of fairly marked degree with moderate thoracic deformity. The deformity was progressive, although she was treated by exercises and braces. Spine fusion was performed Aug. 30, 1918, from the third dorsal to the second lumbar vertebra inclusive. Natural fusion was found between the tenth dorsal and eleventh dorsal vertebrae. Postoperative treatment by traction and exercises. Result, four and one-half years after operation: Fusion is solid, there is considerable decrease in the deformity, which is now stationary, and the health and posture are good.

CASE 26 (22036).—M. M., a girl, aged 7 years at operation, had infantile paralysis six years previously, which left extensive paralysis of

the lower extremities and the abdominal and spinal musculatures. There was a marked curve to the left in the dorsolumbar region and she was unable to sit up unaided. The deformity was progressive although she had exercises and jackets before operation. Spine fusion, Nov. 13, 1918, from the ninth dorsal to the first sacral vertebra inclusive, followed by traction and plaster jackets. Result, four years after operation: Fusion is solid, the deformity decreased and stationary, and she is now able to sit unaided and to walk with crutches.

CASE 27 (14391).—F. S., a girl, aged 15 years at operation, gave no definite history of infantile paralysis, although there was a marked dorsolumbar curve to the right with thoracic deformity. The condition was progressive though treated by exercises and jackets before operation. Dec. 4, 1918, fusion operation was performed from the fifth dorsal to the second lumbar vertebra inclusive, followed by traction. Result, four years after operation: The deformity has not progressed, fusion is complete, carriage and health excellent.

CASE 28 (16693).—I. S., a girl, aged 10 years at operation, had an attack of infantile paralysis at six months of age, which left very severe paralysis of the entire musculature. The spine showed a marked dorsolumbar curve to the right with severe thoracic deformity. She had previous treatment in the gymnasium, with the deformity progressive. Fusion operation was done Jan. 3, 1919, from the second dorsal to the first lumbar vertebra inclusive. Natural fusion was present from the fourth dorsal to the sixth dorsal inclusive. Postoperative treatment by traction and removable jacket. Result, four years after operation: The deformity has progressed over what it was shortly after operation, and there is a question of pseudo-arthrosis in the center of the fused area. The general condition is poor, probably in consequence of the severe thoracic deformity.

CASE 29 (5899).—M. F., a girl, aged 16 years at operation, with date of attack of infantile paralysis not known, although it was probably six years previous. The abdominal musculature was moderately involved and the spine showed a marked dorsal curve, with considerable thoracic deformity. The condition was progressive, although treated by exercises and jackets. Spine fusion, Jan. 7, 1919, from the third dorsal to the first lumbar vertebra inclusive. Postoperative treatment by traction. Result, four years after operation: Fusion is solid, the deformity considerably corrected and not progressive. Posture and health are good.

CASE 30 (27666).—P. L., a boy, aged 15 years at operation, gave no definite history of infantile paralysis, although there was a marked right dorsal curve with considerable thoracic deformity. The condition was progressive. He received previous treatment by exercises. Fusion was done Jan. 15, 1919, from the fifth dorsal to the first lumbar vertebra inclusive. Postoperative treatment by traction and postural exercises. Result, four years after operation: Fusion is solid, the deformity is

Fig. 14. (Case 30.) Condition before operation.

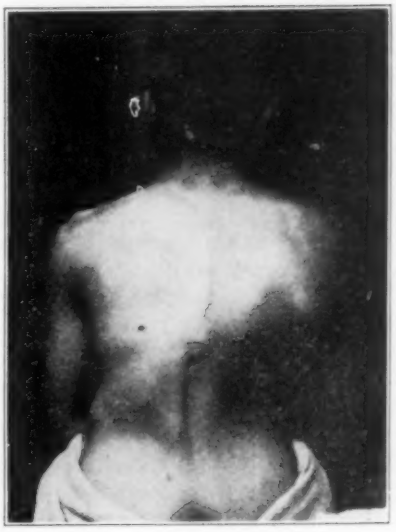

Fig. 15. (Case 30.) Condition four years after operation.

Fig. 16. (Case 31.) Condition before operation.

Fig. 17. (Case 31.) Condition four years after operation.

no longer progressive, and he has excellent posture and health. Figure 14 shows the condition before operation; Figure 15, four years after operation.

CASE 31 (8258).—F. G., a girl, aged 17 years at operation. The date of attack of infantile paralysis is unknown, but there was slight involvement of the lower extremities, and the spine showed a moderate dorsal curve to the right with some angulation of the ribs. Previous treatment by exercises and by jackets. The deformity was progressive, and Jan. 21, 1919, fusion was done from the sixth dorsal to the first lumbar vertebra inclusive. Natural fusion was found between the seventh dorsal and eighth dorsal vertebrae, and between the eleventh and twelfth. Post-operative treatment by traction and postural exercises. Result, four years after operation: Fusion is solid, the deformity decreased and not progressive. Posture and health are excellent. Figure 16 shows the condition before operation; Figure 17, four years after operation.

CASE 32 (9427).—L. P., a boy, aged 9 years at operation, gave no definite history of infantile paralysis, although there was marked involvement of the abdominal and spinal musculatures and a moderate right dorsal curve with pronounced rotation. He was unable to attain a sitting posture without assistance. The deformity was progressive in spite of exercises and jackets. Fusion was performed Jan. 28, 1919, from the fifth dorsal to the first lumbar vertebra inclusive. Postoperative treatment by traction, jackets, and postural exercises. Result, four years after operation: Fusion is solid, the deformity is no longer progressive, and he has good posture and health notwithstanding a fairly severe deformity.

CASE 33 (14289).—N. E., a girl, aged 9 years at operation, gave no definite history of infantile paralysis. However there was distinct involvement of the spinal musculature, permitting a right dorsal curve of fairly severe degree with considerable thoracic deformity. She was first treated by exercises and jackets, but the deformity continued progressive. Fusion was performed Jan. 29, 1919, from the second dorsal to the tenth dorsal vertebra inclusive. Postoperative treatment by traction only. Result, four years after operation: Fusion is solid and the deformity stationary. She has good posture and health.

CASE 34 (29342).—E. H., a boy, aged 20 years at operation. No history of infantile paralysis obtainable, but there was a distinct involvement of the abdominal and spinal muscle groups and a fairly marked right dorsal curve with considerable thoracic deformity. He had no previous treatment, and Feb. 11, 1919, spine fusion was done from the fourth dorsal to the eleventh dorsal vertebra inclusive. Postoperative treatment by traction only. Result, four years after operation: Fusion is firm and the deformity decreased and not progressive; he has excellent posture. Figure 18 shows the condition before operation; Figure 19, four years after operation.

Fig. 18. (Case 34.) Condition before operation.

Fig. 19. (Case 34.) Condition four years after operation.

CASE 35 (10806).—H. H., a girl, aged 13 years at operation, who had an attack of infantile paralysis ten and one-half years previously which extensively involved all extremities and the abdominal and spinal muscles. There was a marked dorsal curve to the left with severe forward pitch and extreme thoracic deformity. The deformity progressed rapidly in spite of treatment by jackets and traction. Fusion operation, May 6, 1919, from the seventh cervical to the eighth dorsal vertebra inclusive, at which time contact was noted between the fourth and fifth dorsal spines with beginning natural fusion. Postoperative treatment by traction. Result, three and one-half years after operation: Fusion solid with no increase in deformity. The carriage is very good except for forward pitch.

CASE 36 (30381).—W. M., a boy, aged 18 years at operation, gave no definite history of infantile paralysis. The spine showed a marked curve to the right involving the entire dorsal region, with severe thoracic deformity. He was in traction before operation, and June 24, 1919, fusion operation was performed from the third dorsal to the twelfth dorsal vertebra inclusive. Postoperative treatment by traction. Result, three and one-half years after operation: Fusion is solid. He has comparatively good posture and health, and the deformity is not progressive.

CASE 37 (5828).—J. G., a girl, aged 8½ years at operation, with probable attack of infantile paralysis six and one-half years previously. There was a marked dorsolumbar curve with exaggerated thoracic de-

formity and sharp forward pitch. The condition was progressive although treated by exercises, plaster, and pre-operative traction. Fusion was done July 2, 1919, from the seventh dorsal to the fourth lumbar vertebra inclusive. Traction after operation. Result, three and one-half years post operatively: Fusion apparently solid but there has been a distinct increase in the posterior curve. Her posture is only fair in consequence of this, but her carriage is better.

CASE 38 (17714).—S. M., a boy, aged 10 years at operation, had an attack of infantile paralysis three years previously, which left marked paralysis of all extremities, and the abdominal and spinal muscles. There was a severe posterior dorsal curve with slight deviation to the right. Previous treatment by brace, exercises, and traction, but the deformity was progressive, and Aug. 29, 1919, fusion was performed from the seventh cervical to the tenth dorsal vertebra inclusive. Postoperative treatment by traction. Result, three and one-fourth years after operation: Fusion is solid. The deformity is less and is stationary. He has good standing posture and there is much improvement in the condition of the extremities.

CASE 39 (11388).—L. N., a girl, aged 14 years at operation, with no definite date of attack of infantile paralysis. She showed, however, slight paralytic involvement of the lower extremities and a marked right dorsal curve with corresponding asymmetry of the trunk. She had previous treatment of ten years' duration by exercises and jackets, with the deformity increasing. Fusion, preceded by traction, was done, Sept. 27, 1919, from the seventh cervical to the eleventh dorsal vertebra inclusive. She had postoperative treatment by postural exercises and traction. Result, three years and four months after operation: Fusion is solid and she has excellent carriage and health. The deformity is decreased and is not progressive. There is exaggerated mobility below the fused area.

CASE 40 (26522).—H. A., a girl, aged 10 years at operation, who had an attack of infantile paralysis eight years previously. There was severe involvement of the lower extremities and of the abdominal and spinal muscles, permitting a very severe left dorsolumbar curve with sharp angulation of the ribs and compression of the thorax. Previous treatment by braces and plaster with traction immediately before operation. The deformity continued to increase, and Sept. 23, 1919, fusion operation was performed from the seventh cervical to the second lumbar vertebra inclusive. She was in postoperative traction and then wore removable jackets. Result, three years after operation: Fusion is solid but the deformity has increased below the fused area. The posture and health are poor, the latter perhaps in consequence of the thoracic compression.

CASE 41 (29182).—M. M., a girl, aged 7 years at operation, had infantile paralysis two and one-half years previously, which left extensive involvement of all extremities and of the abdominal and spinal muscles.

The spine showed a marked right dorsal curve with considerable thoracic deformity. She was unable to sit without support. She had exercises and wore a removable jacket, but the deformity was rapidly progressive, and Oct. 1, 1919, fusion operation was performed from the seventh cervical to the first lumbar vertebra inclusive. She had postoperative traction, and removable jackets and exercises. Result, three years after operation: Fusion is solid and deformity is stationary except for a slight increase in the posterior curve. Her general condition is poor, due, probably, to the severe thoracic involvement.

Fig. 20. (Case 42.) Condition before operation.

Fig. 21. (Case 42.) Condition three years after operation.

CASE 42 (18015).—R. E., a girl, aged 19 years at operation, gave no definite history of infantile paralysis, although the deformity had been noticeable for the eleven years preceding. The spine showed a marked right dorsolumbar curve with severe angulation of the ribs. She had treatment by jackets and exercises, but the deformity was progressive, and Oct. 22, 1919, fusion operation was performed from the second dorsal to the first lumbar vertebra inclusive. Natural fusion was found at the seventh and eighth dorsal vertebrae. Postoperative treatment by traction and postural exercises. Result, three years after operation: Fusion is solid, the deformity is no longer progressive, and she has

comparatively good posture and health. Figure 20 shows the condition before operation; Figure 21, three years after operation.

CASE 43 (32222).—S. P., a boy, aged 15½ years at operation, had infantile paralysis when a small child, exact date unknown. There was moderate involvement of the lower extremities, and the spine showed a marked right dorsal curve with severe thoracic change and forward pitch. He had had some form of treatment in Russia. The deformity was progressive. He had pre-operative treatment by traction, and fusion operation was done Dec. 2, 1919, from the fourth dorsal to the twelfth dorsal vertebra inclusive. Postoperative treatment by traction, exercises, and Knight corset. Result, three years after operation: Fusion is solid and he has good posture and health.

CASE 44 (22914).—D. S., a boy, aged 8 years at operation, had infantile paralysis four years previously. All extremities and the abdominal and spinal muscles were markedly involved and a severe posterior and left dorsolumbar curve was present. Previous treatment by jackets and traction with the deformity progressive. Fusion was done Dec. 10, 1919, from the fifth dorsal to the third lumbar, followed by traction and removable jacket. Jan. 25, 1921, a second operation was performed at which a pseudoarthrosis was found which had allowed the deformity to progress. This was corrected and the result two years after the second operation showed the fusion to be solid. His posture is excellent except for moderate forward slump and slight list to right.

CASE 45 (5554).—J. D., a boy, aged 14 years at operation, had infantile paralysis nine years previously. There was severe involvement of the lower extremities and of the abdominal and spinal muscles, causing a marked right dorsolumbar curve with deformity rapidly progressive. Previous treatment was by jackets and Dec. 19, 1919, spine fusion was done from the fifth dorsal to the third lumbar vertebra inclusive. Postoperative treatment was by traction and removable jacket. When last seen, fusion was solid and he had fairly erect posture, although there was a tendency to list because of the weak musculature between the fused area and the pelvis. Figure 22 shows the condition before operation; Figure 23, eight months after operation.

REPORT OF FOURTEEN INCOMPLETE CASES.

CASE 46 (11383).—P. N., a boy, aged 18 years at operation, gave no history of infantile paralysis. He showed a left dorsal curve with moderate round-back and severe thoracic deformity. He had no previous treatment and the condition was progressive. Fusion operation was performed Mar. 28, 1916, from the fifth dorsal to the twelfth dorsal vertebra inclusive. Postoperative treatment by braces. The patient was last seen in May, 1916, at which time the fusion was holding and the general posture was good. Figure 24 shows the condition before operation; Figure 25, ten months after operation.

Fig. 22. (Case 45.) Condition before operation.

Fig. 23. (Case 45.) Condition eight months after operation.

Case 47 (8897).—J. S., a boy, aged 5½ years at operation. Date of attack of infantile paralysis unknown. He showed marked involvement of the lower extremities, a dislocation of left hip, and involvement of the abdominal and spinal muscles with a severe dorsolumbar curve to the right and thoracic deformity. The condition was rapidly progressive, notwithstanding treatment by braces and plaster. Fusion was done July 27, 1917, from the eighth dorsal to the third lumbar vertebra inclusive. Postoperative treatment by Knight corset. Last seen in June, 1918, when the fusion was found to be solid. The deformity had increased between the pelvis and the lower end of the fused area because the musculature was so feeble.

Case 48 (16727).—M. P., a girl, aged 6½ years at operation, had infantile paralysis one year previously. The lower extremities were severely involved and paralysis of the abdominal and spinal muscles permitted a long, moderate, dorsolumbar curve to the right. She had previous treatment by exercises and braces, but the deformity was progressive, and Dec. 7, 1917, fusion was performed from the third dorsal to the third lumbar vertebra inclusive. Patient died the day following operation—cause: acidosis.

Case 49 (14622).—E. M., a girl, aged 17 years at operation, gave no history of infantile paralysis, but she presented a definite imbalance in the lower extremities and a marked left dorsolumbar curve with sharp angulation of the ribs. The deformity was progressive and

Fig. 24. (Case 46.) Condition immediately before operation.

Fig. 25. (Case 46.) Condition ten months after operation.

painful. Previous treatment was by exercises and jackets. Fusion was performed Feb. 6, 1918, from the fourth dorsal to the first lumbar. Postoperative treatment by traction and steel uprights. Result, three years after operation: Fusion is solid. A slight increase in the deformity is due apparently to instability of the fifth lumbar. Fusion of the fifth lumbar vertebra to the sacrum was contemplated, but the patient was lost track of.

Case 50 (15116).—R. F., a boy, aged 19 years at operation, gave no definite history of infantile paralysis. There was a marked right dorsal curve with severe thoracic deformity and the condition rapidly progressive in spite of braces, plaster and exercises. Feb. 6, 1918, fusion was done from the fourth dorsal to the eleventh dorsal vertebra inclusive. He had no postoperative treatment. He was last seen August, 1919, when the fusion was solid, the deformity much less and he had comparatively good posture.

Case 51 (19619).—T. C., a boy, aged 9 years at operation, had an attack of infantile paralysis six years previously, which left marked involvement of the lower extremities and the spinal musculature. There was a moderate left dorsolumbar curve with the deformity rapidly pro-

gressive. Previous treatment by braces and double fasciotomy. Mar. 1, 1918, fusion was done from the eleventh dorsal to the fourth lumbar vertebra inclusive. Postoperative treatment by Knight corset. Result, three years after operation: Fusion is solid and the deformity slight. The posture of the trunk is good, but there is still much disability from the paralytic condition of the lower extremities.

CASE 52 (24437).—B. H., a young woman aged 30 years at operation, gave no history of infantile paralysis, but there was distinct involvement of the intrinsic musculature of the feet, and patient stated that she had had the spinal deformity for eighteen years. The spine showed a marked dorsal curve with great asymmetry of the trunk. The deformity was progressive and painful. She had previous treatment by brace, and Apr. 4, 1918, fusion was performed from the second dorsal to the twelfth dorsal vertebra inclusive. Postoperative treatment was by traction. When last heard from (examination by outside doctor) fusion was solid, the deformity was no longer progressive and she was free from pain.

CASE 53 (22340).—G. C., a girl, aged 13½ years at operation, had infantile paralysis two years previously, which moderately involved the lower extremities and left a marked right dorsolumbar curve with severe thoracic deformity. She had treatment by jackets yet the deformity was progressive. Fusion was performed June 7, 1918, from the first dorsal to the eleventh dorsal vertebra inclusive. Natural fusion was found at the articulations, laminae, and spinous processes of the tenth and eleventh dorsal vertebrae. Postoperative treatment by traction. Result, nine months after operation: Fusion solid with the deformity no longer progressive; posture much improved.

CASE 54 (17388).—J. R., a boy, aged 9½ years at operation, had infantile paralysis two years previously, with moderate involvement of the lower extremities and severe paralysis of the abdominal musculature. There was a right dorsolumbar curve of slight degree. Treatment by brace, with deformity increasing. July 9, 1918, fusion was done from the ninth dorsal to the third lumbar vertebra inclusive. Postoperative treatment by traction. Result, two years after operation: Deformity stationary and fusion solid.

CASE 55 (18708).—S. M., a girl, aged 17 years at operation, had infantile paralysis when only a few months of age. The lower extremities were slightly involved, but there was a marked right dorsal curve with severe thoracic deformity. Previous treatment by special exercises with deformity progressive. Fusion was performed July 16, 1918, from the second dorsal to the twelfth dorsal vertebra inclusive. Postoperative treatment by traction. Last seen in December, 1918, when fusion appeared to be solid and the deformity much corrected.

CASE 56 (18900).—F. C., a boy, aged 2½ years at operation. Exact date of attack of infantile paralysis unknown, but child had never walked. The lower extremities were extensively involved, as were also the abdominal and spinal groups. The spine showed a marked right dorsolumbar curve with severe rotation. The deformity was rapidly progressive. Previous treatment by jackets and exercises. Fusion operation, Aug. 21, 1918, from the third dorsal to the second lumbar vertebra inclusive. Patient died Aug. 25, 1918, of lobar pneumonia.

CASE 57 (29492).—I. R., a boy, aged 7½ years at operation, had infantile paralysis six years previously. The lower extremities, and the abdominal and spinal muscle groups were moderately involved. There was a slight dorsolumbar curve to the right. Previous treatment by exercises and traction. Fusion was performed May 8, 1919, from the seventh dorsal to the third lumbar vertebra inclusive. Postoperative treatment in traction. Last seen in October, 1919, when the fused area appeared to be solid, the deformity not progressive, and the posture good.

CASE 58 (22144).—M. C., a girl, aged 12 years at operation, had infantile paralysis eight years previously, which severely involved the lower extremities and the abdominal and spinal muscles. Patient had not been able to sit or walk since the attack. The spine showed a marked dorsolumbar curve to the right, with considerable thoracic deformity. The condition was progressive. There was no previous treatment of the curvature, but a double fasciotomy was done to correct the leg deformity. Spine fusion was done Sept. 24, 1919, from the first dorsal to the second lumbar vertebra inclusive. Postoperative treatment by traction. Has not been heard from or seen since discharge from hospital, at which time she was able to sit up and stand with crutches.

CASE 59 (34342).—C. M., a boy, aged 3½ years at operation. Date of attack of infantile paralysis unknown, although there was definite weakness of the abdominal wall and spinal musculature. This caused a sweeping right dorsal curve which was progressive. There was no special treatment to spine except by pre-operative plaster jacket, and fusion was performed Dec. 30, 1919, from the seventh cervical to the first lumbar vertebra inclusive. Postoperative treatment by plaster jacket. Last seen August, 1920, at which time he was still wearing a removable jacket. Fusion solid.

DISCUSSION ON PAPER OF DR. HIBBS.

DR. A. MACKENZIE FORBES, Montreal, Canada: I have been exceedingly interested in this paper written by Dr. Hibbs, as I have remembered the great opposition which was originally shown to this operation.

I am very much pleased indeed to notice that Dr. Hibbs says that in all persons on whom he has operated there was a history of infantile paralysis or that he considered that they had suffered from infantile paralysis. Perhaps he should have said that the scoliosis which affected them was due to infantile paralysis, because from my experience I have always contended that this operation was one that should be indulged in only to save life. I am very much more conservative, as you will note, than Dr. Hibbs.

We in Montreal have had two investigations made, the first by Dr. H. B. Cushing and the second by Dr. F. G. Finley, in order to ascertain the prognosis in those who suffered extreme thoracic deformities. We found that the prognosis was bad. They did not live to old age, but only to early adult life. The majority seemed to die from cardiac conditions.

Now there is one thing about the subject of my friend, Dr. Hibbs', paper which I would like to accentuate: that is, we should get correction first before we ever think of operation. Let us obtain all the correction possible and only then let us operate to maintain correction. I do not believe in operating to get correction. I believe in operating to maintain correction.

I was interested to hear that Dr. Hibbs in certain, perhaps many, of his cases, fused only a few vertebrae. From my point of view it is better in severe cases—and I think we are justified in operating only on severe cases—to fuse the whole spine, or at least half of it.

There is another very interesting point about Dr. Hibbs' experience. He says that he notices very little shock after his operation for fusion of the spine. I feel that he is able to make this statement because of the perfection of his operative procedure and because of his technique: Dr. Hibbs is a finished operator. May not this lack of shock which he claims be due to the fact that in his cases he operates most frequently (certainly in some of those shown here) over a small and limited area? Next, he operates before the deformity is advanced and before the deformity is marked. He, in other words—and he will excuse my using this expression—constitutes himself a prophet and says which cases are going to advance. Perhaps I am too conservative, but I should not want anyone to prophecy what was going to happen to my spine or to the spine of my child. I would want to wait until a serious and progressive deformity had developed. I would then obtain all the correction I could, and then, only then, operate to maintain that correction. I would operate because I could not maintain that correction in any other way. The statements which I have made are proven by the words of Dr. Hibbs. He says that 48 percent have practically normal carriage and posture. Gentlemen, you know that if you are dealing with a severe case of scoliosis nothing in God's world is going to make carriage, and especially posture, practically normal.

Another very interesting thing, and this is my last point: Anatomists tell us that the posterior parts of the vertebrae become bony only after the fifth year. Consequently, should we not delay operation until at least the advent of the fifth year, or better still after the fifth year is past?

Now I want to congratulate my friend, Dr. Hibbs, for there is no one who admires his work more than I. I want to congratulate him on having proved to the surgical profession the efficacy of operation for scoliosis. Dr. Hibbs and I differ as to what cases should be operated on, but I want to congratulate him on what he has proven. He has proven, and I say this without reservation, that operation is not only justified, but it is a valuable method for the treatment of severe and progressive deformities, the correction of which one cannot maintain by other methods.

DR. S. KLEINBERG, New York City: At the Hospital for Ruptured and Crippled we have extended the fusion operation for scoliosis to the non-paralytic cases. We have felt that if the operation is of value in the paralytic cases it may serve to arrest the progress of the deformity in the idiopathic cases. I have operated on about thirty or thirty-five cases and Dr. Armitage Whitman has operated upon a similar number. We believe with Dr. Hibbs that the operation is of value in arresting the deformity. I can recall only two cases in which there was an increase of the curvature after the operation. We have laid a great deal of stress on correcting the deformity as far as possible before operation and have used successfully for this purpose traction on a convex frame.

Dr. Forbes mentioned that very few cases of scoliosis reached old age. In a recent review of 660 cases I found that only 2½ percent were more than 40 years of age. It is, therefore, all the more important to apply treatment early so that the severer grades of deformity may be prevented and the life of the scoliotic prolonged. I heartily endorse the use of the fusion operation for scoliosis.

DR. JOHN L. PORTER, Chicago, Ill.: I think there are some of us here who are interested in asking Dr. Hibbs and Dr. Kleinberg as to the effect of movement of the spine, especially in the non-paralytic cases of fusion of a large number of vertebrae,—say eight to fourteen. Is not the patient's voluntary movement interfered with markedly enough, by fusion of so many vertebrae, to make it impractical in every day life? Of course, that does not cut so much figure in Dr. Hibbs' cases, because his are all extremely severe and the limitation of movement would be greatly over-balanced by stabilizing the spine, but in the non-paralytic cases where the patients expect to use the muscles and get about in the ordinary activities of life, does not the fusion of so many vertebrae interfere with many of their movements?

DR. ARMITAGE WHITMAN, New York City: I think it is rather important that in this discussion we should separate the two classes of scoliosis. Dr. Hibbs made the statement that all his cases were due to anterior poliomyelitis, but in the cases operated on at the Hospital for Ruptured and Crippled we have not been able to take that view. We operated on a series of idiopathic cases which were reported very fully in the Archives of Surgery a year ago. All I can add today is the report of progress since that time. It was a series of eleven cases. Out of this number the deformity remained stationary in all except one. In that one there was a total curve which I had believed corrected before operation. After six months the spine relapsed up to the point at which the lumbar compensated for the dorsal curve. There it has remained for six months. I think that is an interesting point as perhaps bearing out the theory on which the operation has been performed,—that is: the assumption that in these cases there is a primary curve in response to which a secondary curve develops. If we can by any means succeed in arresting the primary curve, the secondary curve should have no excuse for progressing. If we can establish that theory it seems to me we will have a much firmer basis on which to proceed further.

DR. REGINALD SAYRE, New York City: I believe this is a useful operation in these cases of paralysis, in that it may prevent the patient from the necessity of carrying around a support on his back all the rest of his life. Now we notice in paralysis of the lower extremities that sometimes although muscular impairment has not been so very marked, bone growth has been very much interfered with. A leg will be two or three inches shorter than the other though there is a rather fair preservation of the leg muscles. If this same condition takes place in the vertebrae there is one-half of a vertebra growing faster than the other, and no operation will keep the patient from having a progressive deformity. I notice in many of these pictures the deformity has been

progressive, and instead of being arrested the deformity was more marked in some of the results than in the beginning. If these patients are made able to go around without support, if they are free from compressing pain, that is a very good thing. I believe that those are the only cases in which this operation should be done: that is, the cases of paralytic scoliosis. In the series of cases of idiopathic scoliosis which Dr. Kleinberg and Dr. Whitman showed at the Academy, it seemed all that had been done was to add a disfiguring scar to an already crooked back. With it they could not go to a party with the present style of dress.

Dr. R. A. Hibbs, New York (closing the discussion): I have not very much to add to what has already been said, except one word in regard to the so-called idiopathic cases of scoliosis. I believe the majority of those cases are poliomyelitic, and are those cases in which only the intrinsic muscles are involved, and no evidence of the fact is shown until the deformity develops in consequence of their imbalance from paralysis.

If, as Doctor Forbes suggests, the duration of life in cases of scoliosis is shortened by the trunk deformity, it would seem important to operate on such cases earlier and prevent gross deformity, rather than wait until it occurs and then operate.

As has been seen, many of the cases here reported had very great change in their trunks, and I feel very sure that they would have been better off had they been operated on much earlier. All that I hoped to obtain in cases with gross deformity was when possible to correct it in some degree but, more important, to prevent its progress, giving them less fatiguing posture and freeing them from the necessity of wearing supports, etc.

As to the question of fusing spines in young children, there can be no question but that it is perfectly simple and definite that fusion can be obtained in cases certainly as young as one year; indeed young children fuse much more quickly than adults.

ON THE SPONTANEOUS RECOVERY OF CONGENITAL DISLOCATION OF THE HIP.

Lecture Given at the Meeting of the Scandinavian Orthopaedic Association at Stockholm, June, 1923.

By Prof. Dr. H. C. Slomann, Copenhagen.

The spontaneous recovery of a congenital dislocation of the hip is a very rare occurrence, the nature of which has, so far, never been explained. I have therefore considered that it might be of interest to submit two such cases, which I have had the opportunity of observing, along with a short synopsis of the few previously reported cases of the same nature, and the reflections suggested thereby.

First, therefore, we will take the records of the two cases.

Case 1. A little girl of two years, born June 19, 1918, was brought to me in June, 1920. She was the younger of two sisters, the elder of whom I had treated for a congenital pes varo-equinus; otherwise no congenital deformity had been known in the family. Healthy little girl; could walk alone at the age of one; always limped slightly.

On examination I found a slight shortening of the left lower extremity, and one centimeter diminution in the circumference of the left thigh; the head of the left femur on palpation was found to be situated too lateral and too high, quite clear of the artery, and less prominent in the groin than on the right side. The displacement of the head could be most distinctly felt when she was standing. (I recommend that the examination of the position of the head in the case of little children always be made also in the standing position.) Standing on the left leg, Trendelenburg's symptom was distinctly pronounced, and there was a slight limp in the walk. The roentgenogram (Fig. 1) shows the typical picture of a subluxation. On account of the—from my experience—unfavorable phase of the case at the time,* I postponed treatment and requested the parents to come again in six

*If the subluxation becomes a complete luxation, the retention of the head after reposition will be easier, because the limbus acetabuli, previously flattened by the pressure of the head, will have righted itself and increased the depth of the articular cavity.

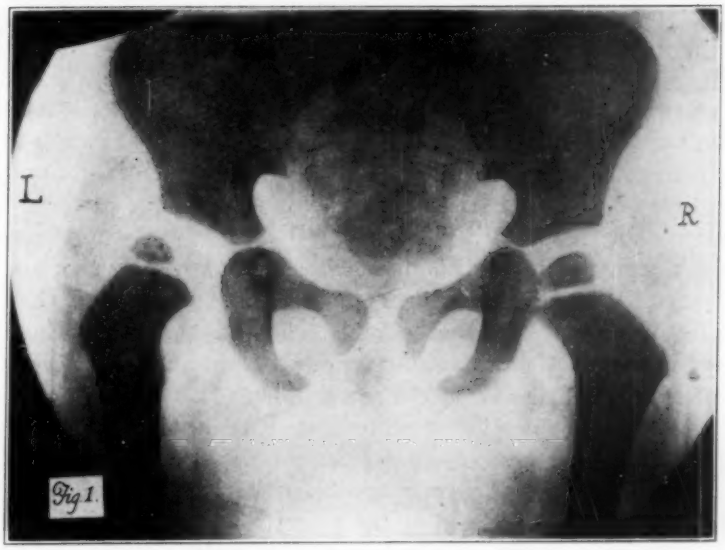

Fig 1.

Fig 2

months' time. They, however, did not come as the limp by that time had almost disappeared; and I did not again see the child, now just about four years old, until a month ago. Now her walk is perfectly natural, and there is only a faint trace of Trendelenburg's symptom when standing on the left leg. The two heads are in quite a symmetrical position in the groins. The left lower extremity perhaps shows a scarcely measurable shortening and the diminution of circumference at the base of the thigh is 2 cm. There is no visible atrophy of the musculi glutæi; the mobility in the hip-joint is about the same as on the right side; only the abduction and outward rotation are very slightly restricted. The roentgenogram (Fig. 2) taken with the points of the feet right in front, as well as that taken in outward rotation, shows the head of the left femur in its normal position, and only a very faint trace of aplasia of the roof of the acetabulum.

Case II. A baby girl of sixteen months, born Feb. 9, 1914, the daughter of one of my colleagues, was brought to me on the 3rd of June, 1915. She was the younger of two children, the elder being a healthy boy. She was nursed at the breast, a bright little girl who had only just begun to walk, and limped with the left leg. On examination I found a slight shortening of the left leg and a diminution in the circumference of the thigh; the head was in too high and lateral a position, particularly very distinctly so when she stood up; and Trendelenburg's symptom was very pronounced when she stood on the left leg. The roentgenogram (Fig. 3) shows subluxation. Treatment was postponed; the limping ceased in the course of six or nine months, and I did not see her again until the 1st of May, 1923, now 9 years old. Her walk in now perfectly normal; there is no shortening of the left leg, and the regions of the hips are symmetrical,—only the left trochanter a little more prominent, due to a slight atrophy or aplasia of the glutæi muscles on the left side. There is still a slight but unquestionable Trendelenburg's symptom when standing on the left leg. Circumference of femur the same right and left, as is also the mobility in the hips; only the outward rotation on the left side is slightly restricted. The roentgenogram (Fig. 4) shows a perfectly normal configuration of the left hip joint, just the same as the right; only the roof of the left joint shows a very slightly diminished development.

I thus regard it as substantiated that with both these children there has existed a congenital subluxatio coxæ, and that the recovery from this pathological condition has in both of them been spontaneous, without any external interference with the state of the joint. Isolated re-

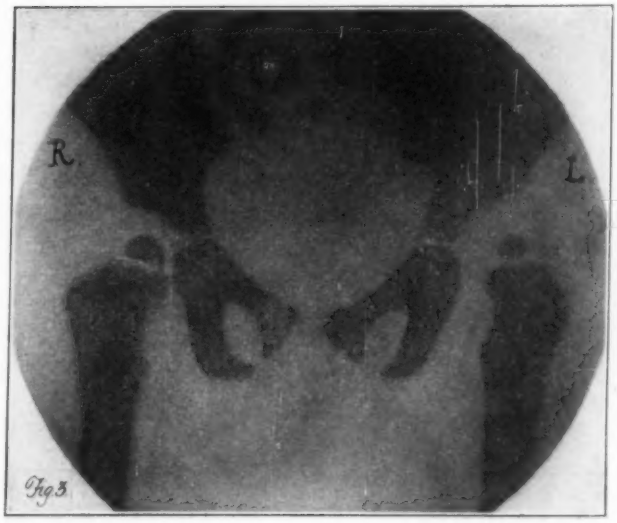

Fig 3.

Fig 4

Fig. 5.

Fig. 6.

ports on cases of this nature are to be found scattered in the literature on the subject, and I have availed myself of this opportunity to, as far as I have been able, collect and systematize them. This has never been done before I believe. I have been able to find altogether twenty-one cases which are published under this heading, but these twenty-one cases, on closer examination, prove to constitute a fairly heterogenous collection. Besides cases of the same nature as mine there are others where a spontaneous functional recovery has certainly supervened, but the anatomical dislocation has continued to exist; again others where the presence of a dislocation has never in reality been substantiated, but only conjectured, etc. I need here hardly go into further details, but have drawn up and submit a classified table which can be used as a short synopsis.

TABULAR SYNOPSIS

SUBLUXATION

4 Cases

1. Piollet (1)*. Left side disloc., female. Diag. 2 yrs. old. Recov. substant. 6 yrs. old. Wore a bandage 2½ yrs.
2. Drehmann (2) Case I. One side disloc., female. Diag. 2 yrs. old. Recov. substant. 4 yrs. old.
3. Slomann Case I. Left side disloc., female. Diag. 2 yrs. old. Recov. funct. 2½-3 yrs. old. Recov. substant. 4 yrs. old.
4. Slomann Case II. Left side disloc., female. Diag. 15 mos. old. Recov. funct. hardly 2 yrs. old. Recov. substant. 9 yrs. old.

NO INFORMATION AS TO THE CHARACTER OF THE DISLOCATION.

3 Cases

1. Joachimsthal (3) Case II. Double disloc., female. Diag. 10 mos. old. Recov. of left substant. 18 mos. old. Confirmed 3 1/2 yrs. old.
2. Joachimsthal (5) Right side disloc. (Multiple congen. deformities) Diag. 18 mos. old. Recov. substant. 2 yrs. old. (Wore in meantime bandage for right-side tibia defect).
3. Bradford (6). One side disloc., female. Diag. 6 mos. old. Recov. substant. 2 yrs. old. (Bradford's Case II is of no importance; he seems only to have heard of it through the parents.)

TOTAL DISLOCATION

5 Cases

1. Drehmann (2) Case II. Left side disloc., female. Diag. 9 mos. old. Recov. funct. 18 mos. old. Recov. substant. 2 yrs. old.
2. Idem. Case III. Left side disloc., female. Diag. 7 mos. old. Recov. funct. 1 yr. old. Recov. substant. 18 mos. old.
3. Idem. Case IV. Double disloc., male. Diag. 6 mos. old. Recov. of left to slight sub-disloc. substant. 13/4 yrs. old.
4. Joachimsthal (3) Case I. Double disloc., female. Diag. 1 week old. (both hips can be passively replaced and redislocated) (anterior disloc. in both knees). Recov. of left hip substant. 10 mos. old.
5. Kopits (4). Left side disloc., female. Diag. 15 mos. old. Recov. substant. 2 yrs. old.

PSEUDO-RECOVERY SUPPOSED TO BE SPONT. RECOV. OF DISLOCATION.

4 Cases

1. Froelich (7) Case I. The roentgenogram shows that it is not a case of anatomic recovery.
2. Princeteau (1). Examined a case presented as spont. recov. dislocat. and found there was no anatomic recovery.
3. and 4. Galeazzi (8). 2 cases of "so-called" spontaneous recovery. This, however, was only functional not anatomic.

TABULAR SYNOPSIS

ATYPICAL CASES.
2 Cases

1. Froelich (7) Case II. A perfectly incomprehensible case. F. declares this to have been double sided at the age of two and to have been presented as one-sided at the age of seven. The photo taken at the age of two however shows only a one-sided dislocation.

2. P. A. Müller (9). Left side disloc., female. Diag. 18 mos. old. ("typic. disloc."). Recov. substant. 3 yrs. old—and 6 mos. after a trauma (fall on the perineum with maxim. abduct. of femora) followed first by more pronounced limping and pains in the hip, then improvement and recovery.

APLASIA OR DEFORMITY OF THE ARTICUL. COXAE, SUPPOSED TO BE THE REMNANT OF SPONTANEOUS RECOVERY OF DISLOCATION.
3 Cases

1. and 2. Wollenberg (10). Two cases of defectively developed hip joints with the head in normal position in the acetab. In neither case has a disloc. of the head been observed at any previous time in the child's life. The presence of the so-called "Gleitfurche" on the roentgenogram cannot count as proof.

3. Rager (11). An anatom. preparation, the interpretation of which as a spont. recovered disloc. is unwarrantable.

*The figure in parenthesis after the name refers to the list of literature references.

According to this there are among the twenty-one cases only *12 genuine cases of spontaneous recovery.*

Of these are: *left sided*: 6
right sided: 1
double sided: 3, but
in these three only the left hip has recovered spontaneously.

Of the twelve cases: male 1
female 10

Age

with diagn.: 1 week to 2 yrs.
with funct. recov.: 1 to 3 yrs.
with recov. substantiated by medical observation:
10 mo. to 9 yrs. (at this time the disloc. had certainly disappeared, but this may have occurred earlier, and presumably in most cases did so).

There are then, including my cases, twelve published instances where a spontaneously occurring, actual recovery of a well substantiated congenital dislocation of the hip can be regarded as established. This is, of course, only an infinitesimal proportion of the observed cases of dislocation, and these twelve cases cannot have any direct influence on our therapeutic relation to this deformity—also for the reason, that

spontaneous recovery evidently occurs, as a rule, before the operative treatment would generally be regarded as indicated. And this is particularly the case if one is inclined, as I for my part am, to defer somewhat the treatment of subluxation (in the hope that the subluxation will become complete luxation). But, nevertheless, these twelve cases appear to me to furnish considerable interest.

If we attempt to realise *how* such a spontaneous recovery can occur at all, we must premise that here, just as in the cases treated, it hinges in the main on two processes, viz.: first: a removal of the caput femoris from an eccentric, luxated, or subluxated position, to a normal, central position in the acetabulum,—in other words, a reposition; and second: a transformation of each separate element of the hip joint in a normalizing direction. This transformation of the constructive elements of the joint towards their normal shape is indeed a process well known to us from the successful cases of replaced dislocation. We are there accustomed to see the osseous nucleus of the head develop in size and shape, the anteversion of the extremitas superior femoris decrease, and the roof of the acetabulum develop over the head. These changes certainly are in the main of a secondary nature, both in the spontaneous and the artificially produced recoveries. The ossification of the head progresses when its function becomes normal;* and when the roof of the acetabulum, that with dislocation seems so obliquely cut off and badly developed in the roentgenogram, after reposition often gradually gets an almost perfectly natural shape, this is not, as for instance Lorenz himself originally considered, the result of a perfectly new formation, but—in any case for an essential part—merely *the progress of ossification out in a preformed cartilaginous roof*, which in an approximately normal form has been present beforehand, but which in its cartilaginous state has not been visible on the roentgenogram. On the border between bone and cartilage then lies the so called "Gleitfurche," which consequently has never in reality been in contact with the head of the femur at all, and most likely has nothing to do directly with the sliding up of the head.—On the contrary, as regards the diminution of the anteversion, it is certainly, in the cases dealt with here, doubtful whether this is mainly a *secondary* or a *primary* phenomenon in relation to the reposition of

*This is a development well known to us also from other parts of the skeleton, for instance from the connection between the ramus desc. pubis and adscendens ischii at the dislocations. With a one sided dislocation the cartilaginous interstice here is always much larger on the dislocated than on the normal side and after reposition it will gradually diminish. (See Fig. 1 and 2.)

the head. It is generally asserted that under normal conditions the anteversion decreases greatly during the first year of the child's life, from about 40° in the newborn, to only 12°, which is generally stated to be the normal size later in life.* If only so much is correct, that in the normal state the torsion decreases greatly during the first twelve months of infancy, and that in cases of dislocation this decrease does not take place in this period, then we can imagine that in the cases of spontaneous recovery here cited, the decrease occurs belated, but as an independent phenomenon, and thus forms a primary factor in the spontaneous recovery. For of this there can be no doubt, that the spontaneous reposition of the head will be favored by a diminution of its anteposition; we all know what a factor this is for the maintenance of the artificial reposition. However, in addition to such a spontaneous diminution of the anteversion, which of course may have a favoring effect, *but nothing more*, there is certainly another factor necessary to ensure the occurrence of a spontaneous reposition; there must be a force present, which can drive the too highly and laterally situated head downward and inward toward the center of the acetabulum, and maintain its position here.

As a factor of this kind, besides the decrease of the anteversion, Drehmann mentions a *diminution of the "Steilstellung" of the head*, that is to say, of *the collum angle*. This in my opinion is a distinct misunderstanding. By this I do not mean only that the angle of the neck has not been shown to be increased in these cases, just as a valgitas of the neck is by no means the rule with a congenital dislocation; but I would point out that such a diminution of the neck angle could not possibly have the effect Drehmann ascribes to it. For it must in these cases, just as in general, be the point of contact of the head with the pelvis, which is the relative fixed point for the position of the femur in relation to the pelvis, whether there is dislocation or not; and if the

*The acceptance of this figure as the normal value for the torsion of the femur is based, in reality, on a misunderstanding. According to Mikulicz (Arch. f. Anat. und Entw. gesch. 1878) the torsion of the femur varies between minus 25° and plus 37°, consequently within a compass of 62°. It lies, as regards two-thirds (82) of the 120 adult femora examined by Mikulicz, between plus 4° and plus 20° inclusive; and as the computed mean for the angle of the torsion in these 82 cases, Mikulicz mentions the 12°. Now this *mean* size has been adopted in the literature on the subject as the *normal* size. But such an arithmetic mean is, in reality, no standard, and as an isolated statement it lacks both practical and scientific value. To show this, it may suffice here to point out, that the mean size of the torsion in these cases *could* be 12°, without a single one of these femurs having a torsion of 12°. As it is, in fact, only 12 out of 120 femora had a torsion of this size.

neck angle diminishes, this process in itself would only be able to move the trochanter upward, but absolutely could not force the dislocated head downward in the acetabulum,—just as little as the formation of a collum varum, under ordinary conditions, could lead to a dislocation of the head downward out of the acetabulum.

As a factor which really would be able gradually to drive the dislocated head downward and inward toward the center of the acetabulum, I can think of only one force: it is that which would be produced *by a shrinking of the dilated capsule of the joint.* This shrinking of the capsule, which, as we know, is so exceedingly important a factor in the ordinary treatment of the congenital dislocation,—indeed, in the period following immediately after treatment, the main factor for the maintenance of the artificially produced reposition—will undoubtedly be able, if occurring spontaneously at the stage of development of the dislocation here in question, both to draw the head downward and inward to its normal position, and, with the assistance of the secondary factors I have previously mentioned, to maintain the reposition thus effected. That the shrinking of the capsule ceases when the formation of the joint has become normal is a phenomenon we also observe in the best cases treated by reposition. I have therefore no hesitation in formulating this proposition: *that it must be a primary shrinking of the capsule that is the main factor in the spontqneous recovery of congenital dislocation of the hip in the small number of cases of this kind that have been substantiated.*

What cause to assign for this primary shrinking of the capsule can only be a matter of conjecture; the conditions which in advance would appear most probable would be partly a traumatic influence, and partly a prolonged confinement to bed, whereby the functional loading of the hip would diminish. None of these conditions are, however, established in any of the cases I have designated as typical cases of spontaneous recovery. On the other hand, such a trauma appears in Müller's case: female—typical left dislocation substantiated at the age of 18 mo.; at 2½ yrs. fall, with perinæum against the floor, legs out at rectangular abduction. Subsequently, for a time, pains and pronounced limping; but then there was an improvement, the limp gradually disappeared entirely; at the age of three anatomic recovery was substantiated. Here indeed is the only case where it is possible to suppose that a reposition has occurred through a trauma and is maintained directly by its consequences, and this is the reason why I must designate this as

an atypical case. In none of the other cases can anything like a reposition due directly to external violence be assumed.

That a subluxation of the hip joint can be replaced by the gradually operating force exerted by the shrinking of the capsule alone, there can hardly be any difficulty in understanding. One would be more inclined to be dubious as to the adequate significance of this force in cases where the complete dislocation is stated to exist. I, however, think that the gap between these two kinds of cases, under the conditions here dealt with, is not so very great; or more correctly expressed, that what in these cases is diagnosed as complete dislocation is yet not distinguished from subluxation by any so sharp and definite demarcation that the difference between the groups of cases is very material for the process in question. I would, in this connection, point out that of the cases of complete dislocation with which we are concerned, five in all, there are four respectively one week, six months, seven months, and nine months old; the eldest, Kopits's case, was only fifteen months old when the dislocation and its character were substantiated by Roentgen examination; and in all of these anatomic recovery took place before the age of two years. At these early ages the dislocation is in very many cases so little rigid and the elements of the joint so little changed and so plastic, that one can well imagine them being affected in the manner here dealt with, even by a weak but steadily operating force. It is indeed asserted (Damany), that in not a few newborn infants one can with the greatest ease dislocate and replace the hip joint without using any particular force. I have never had the courage to try this, but there is no doubt that in the case of infants with unquestionably congenital dislocation one can often with quite a slight movement produce a temporary reposition, and I can give you an instance of this.

It was a little girl (born Aug. 10, 1921), who was brought to me in May, 1923. The mother could see that the right leg was shorter than the left when the child was only six months of age; and ever since the age of twelve months, when she began to walk alone, she has limped on the right leg. It is now manifest that she has a decided right-sided dislocation, with a shortening of about 2 cm., vacuity at the normal place of the head, and the head standing right up under the lateral portion of the ligament. When the leg is bent at the hip, the head glides downward and backward and is felt at the front edge of the iliac fossa (Luxat. supracotyloidea et iliaca, Lange). Trendelenburg's symptom very pronounced. I diagnosed complete dislocation and, with this

diagnosis, sent her for Roentgen examination, and the picture (Fig. 5) undoubtedly suggests complete dislocation. Now Fig. 6 shows a view of the same hip which might have been taken after the completion of a successful treatment, but which in reality was taken immediately after the first. I have here, without any effort or pull whatever, merely held the leg rotated inward with slight flexion and abduction, in the same position which is employed by Galeazzi after reposition by pressure and pull during narcosis, as the primary position in his treatment of congenital dislocation of the hip.

From this I take it, it is evident that in certain—I think in many—cases of congenital dislocation, there are during the tender years, as in the cases dealt with, no sharp demarcations between the different degrees of dislocation, and even the Roentgen examination can in reality draw no sharp line between them. The hip, which in one unforced position is totally dislocated, is, in another, sub-dislocated, and perhaps in some instances, in a third position, replaced. It is not out of the question that such a child, who, when walking, has a complete dislocation, lies with the hip sub-dislocated or almost replaced when sleeping. And thus it is easier to understand that in the case of the infants and little children mentioned here, the hip joints also, which during the Roentgen examination have been capable of appearing completely dislocated, can have been accessible to spontaneous recovery in the way here sketched.

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AN OPERATION FOR THE AFTER TREATMENT OF SOME CASES OF CONGENITAL CLUB-FOOT.*

BY EMIL S. GEIST, M. D., MINNEAPOLIS, MINN.

It has been my experience in a certain percentage of my club-foot "cures" that no matter how well the equino varus is over-corrected and no matter how well this over-correction is maintained, there will always persist a certain amount of "toeing in" when the child is walking.

In other words, the patient may be walking nicely on the bottom of the foot, but the entire foot is turned in, so that when the great toes are approximated, the heels may be two and three inches apart.

In the past, I have tried to correct this tendency toward inversion by means of braces, elastic webbing bands attached to the shoes and brought around the leg in ascending spiral fashion to be attached to the patient's waist, and other devices which have been advocated to overcome this tendency.

If one observes these cases closely, one will see that there seems to exist an inward twist which involves the shaft of the tibia so that when the patella is pointing forward, the feet are rotated inward, and when the feet are placed parallel, the patellae will be found to be rotated outward.

The object of the operation is, therefore, to "untwist" the tibiae. (Fig. 1 and 2). The operation consists of a transverse, subperiosteal osteotomy of the tibia at about its middle third. The fibula is not divided. After the tibia has been cut transversely, it is an easy matter to rotate the foot outwardly to any desired degree, and it may be thus held by means of a plaster cast which extends from the toes to the groin, with the knee flexed. Duration of cast eight to ten weeks.

After having done this operation three or four times, I discovered that Dr. Willy Meyer, of New York, had advocated the same operation for the same purpose about twenty years ago (according to personal communication). Dr. Michael Hoke, of Atlanta, in a recent paper on paralytic de-

*Read at the meeting of the American Orthopedic Association, held in Rochester, New York, June 7-9, 1923.

formities of the feet, gives a beautiful illustration of the same operation in cases of paralytic feet, complicated with tibial twist. I have done the operation ten times out of about one hundred cases, and I have found it to be uniformly satisfactory.

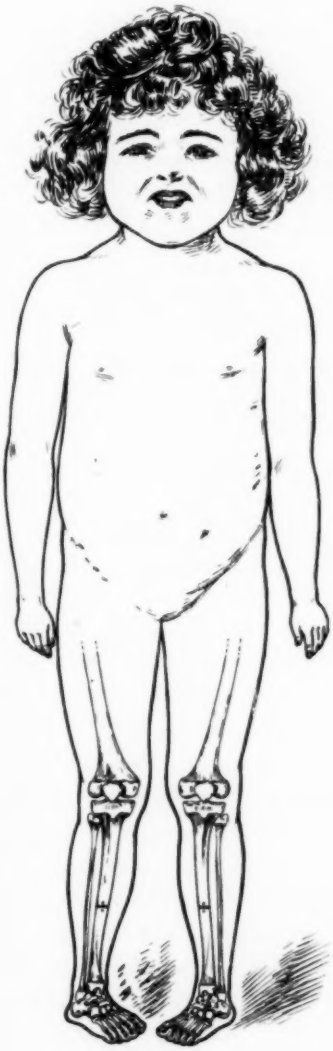

FIG. 1

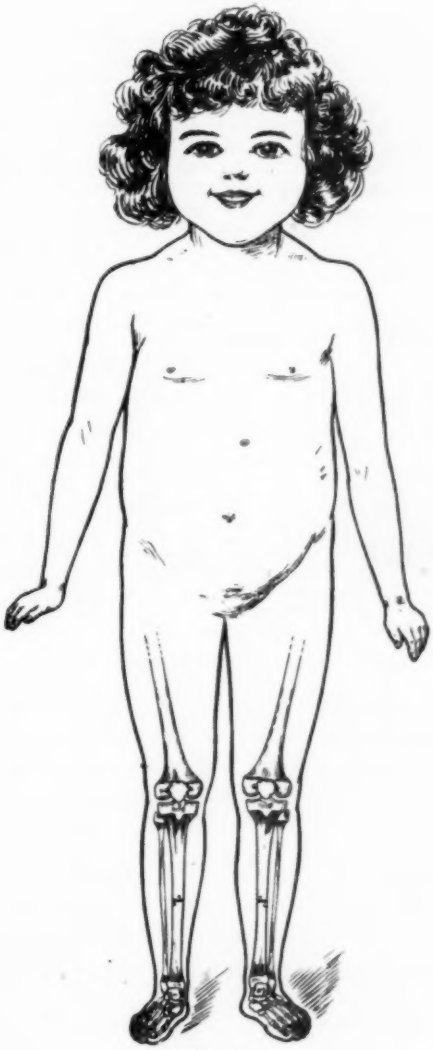

FIG. 2

DISCUSSION ON PAPER OF DR. GEIST.

Dr. A. H. Freiberg, Cincinnati: The only thing I can do is to add a measure of corroboration to what Dr. Geist has said. I am not sure that this is a new procedure because I am of the opinion that it has been employed more or less for a long time. I have not seen this operation performed.

Some of the results we see represent an effort on the part of the surgeon to accomplish by means of an osteotomy of the tibia what he should have done by an operation on the foot. I think there are times when this operation is advisable. I think in each instance it is important to determine whether or not there is a twist in the tibia, and if so, whether the twist can be overcome without operative procedure by proper mechanical management of the foot itself. In order to determine whether there is a twist of the tibia it is necessary to satisfy one's self in regard to the relation between the transverse axis of the upper articular surface of the tibia and the axis of the lower articular surface of the tibia. We have usually done this by putting calipers on both ends of the tibia and seeing in what direction there was a real deviation of the planes which these two calipers occupied.

I believe this operation ought never be necessary except in such instances as are represented by such club feet as have never been treated until the child is quite old. I have never seen an infantile club foot in which there was any necessity for such an operation as advised. Where there is a necessity for this operation I think it can be looked to as a perfectly satisfactory method of correcting the deformity.

Dr. Emil S. Geist, Minneapolis, Minn. (closing the discussion): While Dr. Freiberg said the operation was well known, no reference of it is made in the literature. That is to say, this operation does not seem to be practised much in the after-treatment of congenital club foot.

It has been so satisfactory in my hands that I do not hesitate to present the operation again. It goes without saying that the tibial twist can and should be taken care of in most cases at the time of the treatment of the club foot itself. There are cases, however, when I believe this will be found impossible and it is in just such cases that I think this operation will be found of value.

A CASE OF SNAPPING SHOULDER.*

BY W. ROWLEY BRISTOW, LONDON, ENGLAND.

In May of this year a lady was brought to see me complaining of trouble in the right shoulder. The disability consisted in an inability to use the arm freely in the abducted position: when she attempted this she frequently experienced a painful snap in the region of the shoulder. She then carefully brought the arm to the side and was more or less incapacitated from using it for the ensuing twenty-four hours, on account of an aching pain which gradually passed off.

HISTORY.

Her age is thirty-one, and she dates the trouble from an accident which occurred when she was about sixteen, when she fell and hurt her shoulder. In addition she had a second fall about two months later.

She complained that after these accidents she could not lift anything heavy or put her hand to her head to do her hair for some eighteen months. Massage was carried out for a long period, and the arm had recovered up to a point. It had regained its power for ordinary things, but she had been unable to play games, and even with ordinary care the repeated "dislocations," as they were called, could not be avoided.

STATE.

On examination, nothing abnormal could be detected by inspection or palpation. The patient was very nervous about abducting or elevating the arm, and about rotating the shoulder with the arm abducted, but she was able to carry out all these movements perfectly well. There was no evidence of limitation of movement in any direction.

X-Ray examination revealed no abnormality.

She was then asked to endeavor "to put out the shoulder" by making a sudden movement of abduction and rotation, and she did this. There was a slight click—not an audible snap—and she immediately supported the right elbow with the left hand, brought the arm down to the side, and said it was paining her.

*Read at the Annual Meeting of the British Orthopaedic Association. October 19, 1923.

DIAGNOSIS as a result of the examination.

It was clear:

1. That there was no dislocation or even subluxation of the shoulder joint.

2. That there were no adhesions about the joint; and the only reasonable explanation of the phenomenon appeared to be that a tendon slipped either over another tendon or over a bony prominence: in this case the lesser tuberosity of the humerus.

In a short paper published in the British Medical Journal in January, 1923, Mr. Verrall describes a somewhat similar condition which he ascribes to a slipping of the short tendon of the biceps over the lesser tuberosity. He goes on to say that cure is certain in two or three weeks, with rest and relaxation of the biceps.

TREATMENT.

As the condition had lasted for some fourteen or fifteen years and was getting worse—that is, the temporary disablement was of more frequent occurrence—I suggested that an exploratory operation should be undertaken, if the patient regarded her disability sufficiently seriously to warrant a scar over her shoulder. The readiness with which she acquiesced gave, I think, some indication of the seriousness of the lesion.

Preparatory to operating, I investigated the anatomy of the part with Professor Parsons in the dissecting rooms, in order to see the exact relationship and appearance of the short head of the biceps and the lesser tuberosity in various positions of the arm.

At operation, on cutting down in the short head of the biceps, we found that the condition was abnormal, in that from the outer side of the short head of the biceps muscular fibres were taking origin. These muscle fibres ran downwards and outwards towards the long head. We did not enlarge the wound to explore their insertion. It could easily be demonstrated, on abducting and rotating the arm that it was this fleshy muscle which rode over the lesser tuberosity. There was no evidence of an adventitious bursa. We therefore removed that part of the muscle which could come into contact with the lesser tuberosity,—about one inch, and with it a strip of the tendon of the short head, to which it was attached.

The recovery was uneventful and the operation has, so far, cured the disability, and the patient is now playing Badminton and tennis, which she has never been able to do before.

Immediately after the operation, we returned to the dissecting room and explained the findings to Professor Parsons. He told us that the muscle was the rotator humeri—a constant muscle in lower mammals, and a not uncommon abnormality in man. The muscle is found in about one body in twenty in his opinion. He wrote me as follows:

"The muscle is a constant one in the lower mammals of all orders, and forms the upper element of the tripartite coracobrachialis. When it turns up in Man, which it does quite frequently, it is known as the "rotator humeri" and is always inserted into the neck of the humerus above the latissimus dorsi tendon.

It has been held by some people that the fact of the musculocutaneous nerve piercing the coraco-brachialis in Man is explained by the coraco-brachialis having the upper (rotator humeri) and middle parts coalesced and thus enclosing the nerve between them.

That this is not the case is proved by the frequent reappearance of the rotator humeri in Man with the nerve still piercing the coraco-brachialis.

It is very refreshing to find that time spent in grubbing at Mammalian Myology should have been of practical use in relieving trouble!"

EVOLUTION OF THE LONGITUDINAL ARCH OF THE HUMAN FOOT.

BY DUDLEY J. MORTON, M. D., MILFORD, CONNECTICUT.

ACKNOWLEDGMENT.

The opportunity to follow out this research has been extended to me through the kind invitation of Dr. William K. Gregory, Associate Professor of Vertebrate Paleontology at Columbia University and Curator of the Department of Comparative Anatomy of the American Museum of Natural History, New York. I am indebted to the Museum and to Professor Gregory for the use of extensive material from recent and extinct primates and other mammals, but more particularly for Professor Gregory's hearty and invaluable co-operation and help. I would acknowledge the courtesy of Mr. Carl E. Akeley and Mrs. Herbert Lang, also of the Museum, in the loan of material and for valuable information regarding the habits of the great apes. Professor G. S. Huntington, of the College of Physicians and Surgeons of New York, Professor R. S. Lull and Professor H. B. Ferris, of Yale University, have been most cordial in extending to me their help and the privilege of using material of their departments. I also wish to express my gratitude to Dr. R. B. Osgood, of Boston, whose friendly and professional interest as an orthopaedic surgeon has been a very welcome source of encouragement and inspiration.

INTRODUCTION.

Let us not start by eulogizing the human foot or by making extravagant claims as to its beauty or its physical and mechanical perfection. Every orthopaedic surgeon sees many feet which are so badly distorted by faulty footwear and other causes that he may be pardoned a sense of pleasure at the sight of a well-formed and unspoiled foot. But when we read such reports as Dr. R. J. Cook's statistics of male university students,[1] showing that over three-fourths of the fourteen hundred students examined presented a recognizable weakness (pronation), and think of the amazing proportion of army applicants rejected because of foot disorder alone (as recorded in the Surgeon-General's office), then must we admit that the mod-

ern foot of civilized man, as a perfect mechanical structure, is somewhat of an exception.

Looking directly at these facts and analyzing them to obtain their full significance, we cannot but recognize that they disclose a very serious problem, for they show that:

(1) Disorder of the feet is the most common and most widely spread form of physical impairment among civilized peoples today (with the sole exception of dental defects), and has already reached a stage where over three-fourths of the nation's youth enter adult life with an acquired weakness that may at any time develop into a source of actual disability.

(2) These foot disorders are clearly the result of factors introduced by the civilized mode of living. The causative factors are continually being intensified and augmented, particularly in and about densely populated centers which hold the great bulk of our people; hence, we may not look for conditions to improve, but for them to become worse and more extensive.

(3) No other common disorder can compare with arch trouble in its baneful influence upon the working efficiency and welfare of the individual, mentally or physically. Its cumulative pernicious effect upon the life and energies of the nation is beyond computation, and surpasses by a very large margin similar results from any other physical cause.

When Army Recruiting statistics demonstrate that our fighting forces are so greatly reduced by this source of disability alone, it deserves to be recognized as a matter of national importance. Certainly no other factor so detrimental to the strength of our armies would be allowed to continue, without energetic measures being adopted to overcome it. Because it is hardly conceivable that one hundred per cent. of our fighting strength would ever be called upon for service, of even greater import than our responsibility for national security is our indicated duty toward the younger and future generations. Dr. Cook's statistics show that of those young male university students who were supposedly at the height of their physical prime and who came from the most favored walks of life, 40 per cent presented second or third degree of flat foot (29.5 per cent and 9.8 per cent respectively). They had passed from a stage of potential weakness to one in which the probability of future painful foot disorder, or at least of functional impairment, had become almost inevitable.

These statistics do not represent a widening compass and an increas-

ing severity of a hereditarily transmitted deformity, but they show the results of inherited factors of a civilized environment through which postnatal impairment of the foot *is acquired*. Fortunately, there is a big difference, for in the first case, little could be done to inhibit the progress of an evil which threatened congenitally to become more wide-spread in each succeeding generation. The actual condition, however, offers a much more favorable prospect. The new-born foot is primarily a properly designed but uncompleted organ, which, during the period of growth and ossification of its bones, is as susceptible to good influences quite as much as to harmful ones; consequently the wide prevalence of foot disorders should not be regarded as inevitable, but as unnecessary and preventable to the degree that the causative factors can be overcome or controlled.

Foot disorder, like decay of the teeth, proceeds to a well advanced stage before the "hurt" is felt. Of the two conditions, foot trouble has decidedly the more far-reaching and more deleterious effects upon the life and activities of the individual. It seems quite possible then, in view of what American dentistry has done in the way of prevention and educational propaganda for the care of dental defects, that much can also be achieved in the more serious problem of the feet.

To institute and to put into energetic action a properly organized and purposeful effort to meet this problem is the obvious duty of the orthopaedic men of this country. This is clearly indicated by the nature of the work assigned to them in the creation of our armies during the recent war. Giving relief to foot sufferers is a big part of our present work, but to lend some of our efforts toward a concerted action in order to mitigate the prevailing causes of foot disorders and to protect the younger and coming generations against such evil, will accomplish a bigger deed that would be a worthy heritage for posterity. A very considerable advance has already been made in this direction. Popular footwear of today is greatly improved over what it was a few years ago. Institutions of physical welfare have given the problem a great deal of thought, and even attempts at legislative measures for improving conditions have been made. The value of the latter is open to question, for by educational means only can the co-operation of the public be won and held. Gratifying as the present effect may be, it is hardly commensurable with the size and importance of the work to be done.

It was after the seriousness of the foot problem had been impressed upon the writer from its clinical side as well as from the national aspect (as revealed by the Surgeon-General's report), that he undertook these studies, in the hope that an understanding of the evolutionary development of the human foot would prove of definite value to the profession by yielding a fuller comprehension of the weaknesses of the foot and possibly by indicating new methods of prevention and treatment.

That these disorders prevail so extensively is no fault of Nature, but is due to man's disregard and forgetfulness of his own physical welfare.

Remarkable as are the workings of Nature, her accomplishments are handicapped because she is necessarily a remodeller instead of a creator. She reconstructs material that lies at hand, so it is not strange that when she perfects a structure for specialized usage that susceptibility to certain weaknesses should develop and increase as specialization is carried to a high degree, as has been done in the human foot.

The study of evolution is no more nor less than an attempt on our part to follow Nature's remodelling operations. Some of these re-adaptations appear at first to be clumsy experiments, but when we learn more of the history of the re-adaptation and of its past and present function, we may see some of the reasons for the steps that Nature followed. From what is definitely known about the history of the locomotor apparatus in vertebrates, it is evident that in the modification of a given style of locomotor apparatus from one medium to another, Nature has had to make her organic machines conform in the most effectual and available way to the unchanging laws of mechanics. These laws work in a manner by which definite and predetermined results will be obtained; hence, in the study of the evolution of the human foot, we deal with mechanical principles whose effects we, as orthopaedic surgeons, are familiar with and have daily opportunities to observe.

ORIGIN OF THE HUMAN FOOT.

As has been maintained by numerous authors since the time of Darwin[2] and Huxley[3], the human foot is derived from a highly developed arboreal grasping type of foot which had many characters in common with the feet of the modern great apes. This statement naturally introduces the subject of the Origin of Man, which would require too much space to be considered at length in this paper; however, a synopsis of the chief points which bear upon the very early development of the foot cannot be avoided.

The reader is referred to the various works by authorities upon human evolution and comparative anatomy of the primates, also to current writings by the author[4], for more detailed discussion of the larger subject. Suffice it to say, that the bulk of evidence definitely indicates the correctness of Darwin's conclusion that man originated in the ancestral great ape stock, and the present studies of the human and lower primate feet clearly add further evidence to that increasingly obvious conclusion. For the purpose of a more comprehensive understanding of the development of the modern human foot, it is pertinent to review briefly the principal early evolutionary changes which led up to the development of the ancestral great ape foot.

EARLY EVOLUTIONARY MODIFICATIONS.

The origin of primate life took place in the trees,—that is, the original primates were the descendants of small terrestrial quadrupeds which had already adopted tree life.[5] Thus, all primates may be traced back to a primitive arboreal stock. The very early forms were not the agile, acrobatic creatures we now see, but were timid, cautiously moving animals which clung tightly to the supporting branches. Their hind feet were characterized by long digits, short metatarsals, and widely divergent halluces—feet that had been developed by and for a secure clutching grasp. Such a foot has, in many of its characters, been retained by the Lepidolemur (Fig. 1.) but with mild aberrant modifications. This lemur, therefore, retains more closely the habits of the ancient primates than does any other of the modern primates. It is one of the lowest of living primate forms in its structural characters; and its movements are very deliberate.

THE CURSORIAL STAGE.

The next well marked stage in development was one in which long continued arboreal life had removed fearfulness in movement by establishing a keen sense of equilibrium. No longer was there the necessity for tight grasp; in fact, in its usual manner of locomotion the animal had discarded the use of the grasp of the foot, except upon the smaller swaying branches. These animals ran along the branches of the trees as they would upon the ground, balancing themselves upon the distal ends of the middle metatarsals, in the manner in which terrestrial quadrupeds ordinarily run on the ground. Definite structural changes were associated with

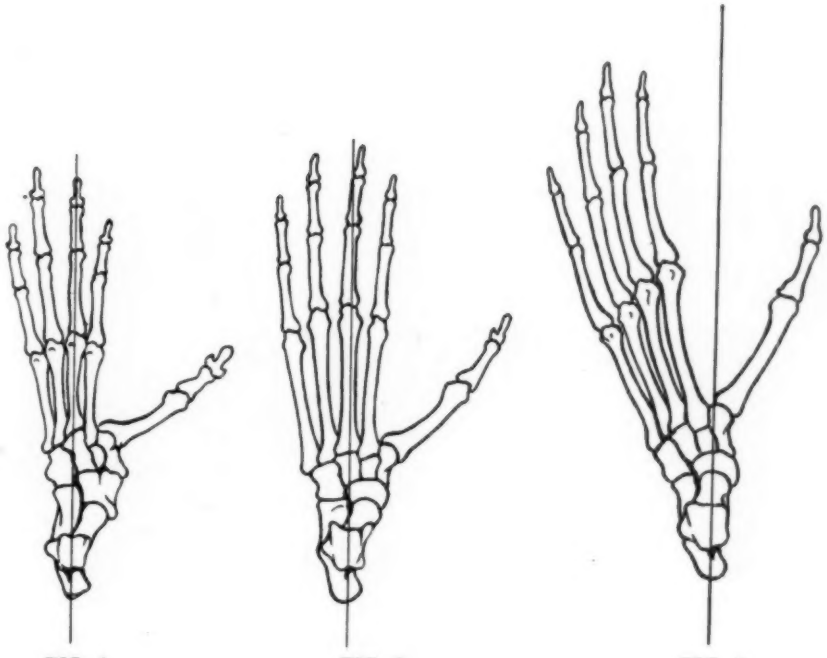

FIG. 1 FIG. 2 FIG. 3

Fig. 1. Lepidolemur foot. Primitive characters, short metatarsals, strongly developed and widely divergent hallux, very long fourth digit, primitive line of leverage through third metatarsal bone.

Fig. 2. Macaque foot. Cursorial, lengthened metatarsals, less widely divergent hallux, primitive line of leverage.

Fig. 3. Gibbon foot. Very long digits and metatarsals, humanoid line of leverage between first and second metatarsal bones, head of second metatarsal more distally located than that of third, small heel.

this alteration in the mode of locomotion, which are probably best represented in the foot of the Macaque (Fig. 2). The metatarsals became longer, as in active terrestrial quadrupeds, the hallux lost some of its wide divergence, and the fourth and fifth digits which, in the earlier types of foot were very long (particularly the fourth, which was the longest) became reduced in length so that the middle digit extended beyond the others. Vertical movements in the trees and the improved ability to maintain balance had established "squatting" as an habitual and frequently used posture.

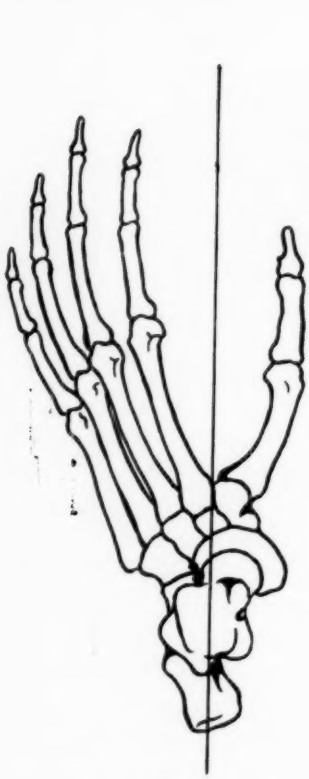

FIG. 4

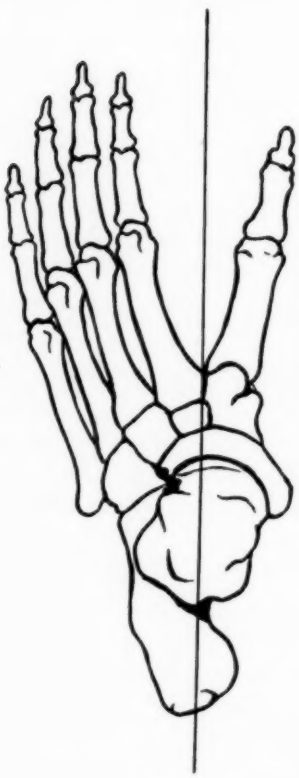

FIG. 5

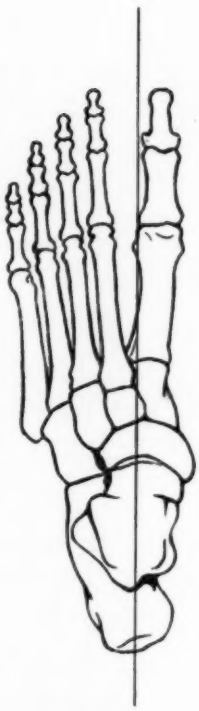

FIG. 6

Fig. 4. Chimpanzee foot. Humanoid line of leverage, arboreal characters similar to that of gibbon, but not so highly specialized.

Fig. 5. Gorilla foot. Terrestrial habits, shortened digits and metatarsals, humanoid line of leverage, stout development particularly noted in first and second metatarsals, reduction of metatarsal torsion, heavy development of the heel.

Fig. 6. Human foot. Line of leverage between first and second metatarsals, slender development due to concentrated action of vertical forces moving longitudinally along the inner border of foot; very short digits, powerful hallux, massive heel.

ALTERATION IN THE LINE OF FOOT LEVERAGE.

Now a basic alteration of the foot occurred in certain of the primates which was associated with general increase in size. The greater span of the foot, conditioned by the larger growth of the animal, permitted a grasp

upon the larger branches which heretofore could be used only upon the smaller ones. The habitual use of the grasp was promoted because it furnished more efficient balancing ability and correspondingly opened up greater freedom in vertical movements. Prior to this change in size the line of leverage action through the foot followed the long axis of the third metatarsal, (Figs. 1 and 2), a condition which had been inherited from pre-primate life. This line of leverage prevails among mammals generally, running through the third metatarsal bone or between the third and fourth, but is never presented toward the medial side of the foot.

The basic change referred to is the establishment of the line of foot leverage between the first and second metatarsals in these larger primates. That this change is a result of increased size is borne out by the fact that it is not only characteristic of the great apes but may also be seen in the larger species of American monkeys. It is also obviously due to the grasping function of the foot in arboreal life, since it is to be seen nowhere else, except in man, and is recognized by the more distally extended position of the head of the second metatarsal bone beyond that of the third (Figs. 3, 4, and 5). For want of a better term the writer has designated this new development as the "humanoid line of leverage" to distinguish it from the "primitive" line.

The importance of this change can hardly be over-emphasized for *it would be extremely difficult to explain man's possession of this character other than by his origin in an ancestral, highly-arboreally developed primate which possessed it.* The new line of leverage has a most important bearing upon the ultimate evolution of the human foot.

THE ERECT POSTURE.

With the adoption and continuous use of this balancing grasp of the hind feet, the mode of locomotion underwent an equally profound change. The feet were now used chiefly as a means of support, while movements in the trees were more and more accomplished by swinging on overhead branches with the arms. This method of locomotion has been called by Sir Arthur Keith "brachiation," and is peculiar to the anthropoid apes. The important result that followed this alteration in the manner of moving from one location to another was the almost continuous use of the upright posture. Previously the vertical position of the spine in squatting was alternated with a horizontal position conditioned by the animal's quad-

rupedal gait; now the vertical position became practically constant, both in squatting and in locomotion. In addition, the legs tended to become more and more extended from the body. Hence, a completely erect posture was developed which included both body and legs.

The fossil femur of Dryopithecus,[6] an ancient anthropoid ape, definitely shows by the structure of this bone that it belonged to a primate which used the upright gait more frequently than any of the living anthropoid apes. Going back still further, to the very early part of the Miocene, fossil remains of an ancient gibbon, which differed very slightly from the modern forms, clearly prove that the erect posture is an exceedingly ancient characteristic of the great ape stock and antedates the generally estimated time of the human origin.

The semi-erect attitude of the larger anthropoid apes should be regarded as a secondary retrogressive change, caused by an over-development of the upper extremities by a too long-continued use of brachiation, and a corresponding under-development and enfeeblement of the lower extremities owing to their more passive function. The long powerful arms, the short, weak legs and the relative unfamiliarity with ground life, definitely promotes the imperfectly erect posture assumed by these animals when on the ground.

INDICATED CHARACTERISTICS OF THE PRE-HUMAN FOOT.

In order to analyze comprehensively the evolutionary development of human longitudinal arch, it is necessary to determine as accurately as possible the type of foot in which it developed. At first glance, this may seem to place the study upon too speculative and hypothetical a basis to be of actual value. Such, however, is absolutely not the case. In regard to the relationship of man to the lower primates, and in particular the closeness of his relationship to the great apes, while all the evidence may be considered "circumstantial," it is also eliminative; the abundance, as well as the positiveness, of certain parts of the evidence (such as the anatomy and histology of the brain) should carry conviction even to the most skeptical.

Following the recognition of man's closest relationship to the great apes, the next step is the realization that the human characteristics, both mental and physical, are definitely the result of his adoption of terrestrial life after the erect posture had been acquired by previous arboreal habits.

No part of the pre-human frame would be so greatly or intensively in-

fluenced by this change of environment as would the feet, for in terrestrial life the most powerful mechanical forces which involve the body-frame—the weight of the creature—were thrown completely upon the feet while in addition, the previously used arboreal grasping function was discarded. Here is presented a profound change in function.

"WOLFF'S LAW" IN EVOLUTIONARY CHANGE.

The action of mechanical forces upon modern foot structure follows definite and unswerving laws which, we, as orthopaedic surgeons, above all others, should not fail to recognize. Those changes, the result of altered function due to abnormalities, follow the phenomenon known to us as "Wolff's Law." The same mechanical laws which are expressed in the structural alterations following physical disorders are revealed in the comparative analysis of the various types of primate feet and their respective manner of usage. *Characteristic function and distinctive structure go hand in hand.* Hence, when the manner of use of a certain type of foot undergoes a change, modification of the structure is inevitable. Furthermore, a proper analysis of the change in the operation of mechanical forces involving a certain structure, will enable one to foretell the resulting modifications. On these grounds, we may deny the purely speculative character of our determination of the architecture of the pre-human foot and its subsequent modifications.

THE DRYOPITHECUS STEM.

A very careful and extended analysis of the various types of primate feet (human, anthropoid ape, and monkey), has led the writer to conclude that the human type began its distinctive development at a stage when the ancestral great ape had not begun to take on its present large size. A detailed report of these studies is published elsewhere.[7] The estimated form of foot would be peculiar to that of an early, small sized "Dryopithecus" whose general characteristics may be given as follows:—

A highly developed and agile, arboreal primate about the size of a large gibbon, but stockier in build. It used the erect posture in squatting, brachiation, and frequent bi-pedal locomotion both in the trees and on the ground. (Its movements were like those of the modern gibbon except that it had not acquired the high development of brachiation displayed by that animal). It was tailless, and the arms and legs were of about equal

length. The time is estimated to be in the early portion of the Miocene period. From this ancient stem, the gibbon branch first, and later the orang, had already been given off, but it was still parent to chimpanzee, gorilla, and man as its modern representatives.

THE EARLY DRYOPITHECUS FOOT.

The foot of this early anthropoid ape as I conceive it (Fig. 7), was a typically arboreal grasping foot which, in a general way, combined the general features of the chimpanzee and the gibbon feet. It resembled a large Macaque foot in its proportions, but the second metatarsal extended beyond the third, in accordance with the establishment of the humanoid line of leverage, (Fig. 6). The os calcis was of moderate size. The foot was flexible with but slight development of ligamentous structure. The transverse mid-tarsal arch was shallow. The foot was held in a slight degree of arboreal "supination." The metatarsal bones presented a marked torsion of their shafts, throwing the hallux and digits into the characteristic position for arboreal grasp, as displayed by the modern apes. The respective lengths of the digits corresponded also to that of the arboreal primate foot—the third being the longest. In other words, the foot was a typical arboreal ape foot, differing only in its proportions from similar modern types.

TERRESTRIAL OR HUMAN MODIFICATIONS.

The first thought to be thoroughly fixed in our minds before considering the subsequent modifications, is that the terms "human alterations" and "terrestrial alterations" are, in this case, different phrases for describing the same group of changes. At least, *in so far as the foot is concerned, "terrestrial" alterations comprise the "human" changes and could not have been started until life upon the ground had become to a certain extent habitual.* This last fact is an obvious one, but one which does not always seem to be fully realized by those who think of the early Man-like ancestor as an arboreal being. All the evidence points to the fact that tree habits had long been given up ere *human* changes in face and form were acquired.

Secondly, in the analysis of the altered mechanics produced by the terrestrial usage of an arboreal foot, we must have a clear understanding of the position such a foot would assume on the ground under superimposed

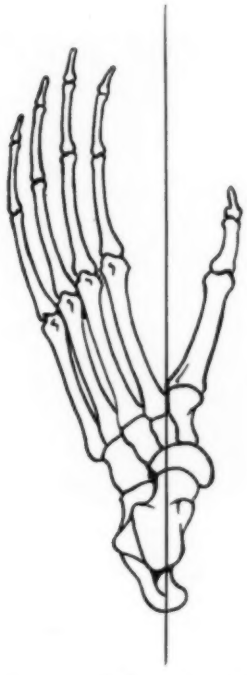

Fig. 7. Dryopithecus foot. (Hypothetical). Similar to the gibbon foot in general characteristics, but somewhat stouter in build. Humanoid line of leverage.

body-weight. The importance of this point is emphasized because there prevails generally the opinion that in some way the longitudinal arch of the human foot is a direct modification of the previous supinated posture. This view in my judgment can be demonstrated to be incorrect and contrary to any applicable mechanical principle, although it seems to find favor among some of our highest authorities.[8] The reasons for this statement will be given below.

SUPINATION.

Supination, as ordinarily presented by the arboreal foot, is not a typical inversion of this member. The position may best be understood by describing the grasping posture of the arboreal foot as it is usually employed in locomotion upon the branch of a tree. The heel is positioned above the center of the upper surface of the supporting branch, while the fore

Fig. 8. Photograph of dissection of an adult gorilla foot loaned by Mr. Carl E. Akeley. A well developed peroneus tertius tendon (indicated by the small arrow) springs from the common belly with the extensor muscle to insert in the head of the fifth metatarsal bone. This tendon was as fully developed as is generally seen in dissections of human specimens.

part of the foot is directed somewhat downward in order that the hallux and digits may close upon the opposite side of the branch. In this position the inner portion of the sole, from the heel forward, is actually facing downward, while the inverted portion consists of only the triangular area extending from the outer border of the mid-tarsal region, widening anteriorly to include the outer metatarsals and digits. Hence, the typical arboreal "supination" is not a true supination of the entire foot, but merely an inversion or dropping of the outer anterior portion of the foot, conditioned by the cylindrical contour of the supporting branch.

When this type of foot is placed upon a flat surface the outer border naturally is first thrown in contact; but, since the center of body pressure is placed well to the inner or medial side of the outer border, and as the arboreal foot is a flexible one, the inner border is forced down until it also comes in contact with the supporting surface. This movement is made the more positive because of the abruptly inward and downward slope of the calcaneal facets which support the astragalus, whereby this bone, carrying the body-weight, is thrown strongly toward the inner border of the foot.

The result is that the foot becomes completely flattened, and not only is the inner border of the foot in contact with the ground, both at the scaphoid area and at the first metatarsal head, but the bulk of body-weight is actually borne by the inner portion of the foot. It is this fact that has insured the retention of the line of leverage between the first and second metatarsal bones in the ultimate human foot, and caused the inner border to be more stoutly developed and longer than the outer.

SUPINATION AND THE LONGITUDINAL ARCH.

If, according to the prevalent idea, the "supinated" posture had been retained and modified to form the longitudinal arch, its retention must inevitably have caused the line of leverage to have been transferred to the outer border of the foot, while the inner border would have been relatively functionless. In the resulting development, the outer border would have become hypertrophied and the inner, atrophied, so that if the process had not eventually led to a distortion worse than our most advanced cases of talipes equino varus, it at least would have given us feet with the great toe where the little one should be, and vice versa. But such development had no chance whatever of occurring, as the flexible arboreal foot was absolutely incapable of sustaining its supinated posture under the weight of the body when on the ground. *What did take place was a complete crushing down of that supinated foot, whereby the active mechanical forces were so positioned as to make possible the development of the human rigidly arched structure as a product of leverage.*

PARALLEL CHANGES IN THE GORILLA FOOT.

The modern gorilla is almost completely a terrestrial animal and although the time of its adoption of terrestrial life has undoubtedly been quite recent compared to the time when man made the change, nevertheless, the intervening period has been of sufficient length to effect certain alterations of the foot (Fig. 5), which are similar and parallel to those that occurred in the foot of early man. The gorilla foot is definitely plantigrade, the heel showing a very massive development in comparison with that of the arboreal chimpanzee. The digits and metatarsals have become shorter, the supinated posture is lost, and the strong development of the first and second metatarsal bones over that of the three outer ones clearly shows that they are used, in a distinct leverage function. The arboreal twist of the

metatarsal bones has been reduced in the adult gorilla fully fifty per cent. of the difference presented between the metatarsals of the chimpanzee and of terrestrial man. This alteration has greatly impaired the grasping function of the gorilla foot.

As added evidence of the parallel terrestrial development of gorilla and man, it may be of interest to report here that in the feet of two gorillas which the writer has had the opportunity of dissecting, peroneus tertius muscles were found. In the first specimen (adolescent) the muscle was definitely present, though rudimentary, but in the second specimen (adult) the tendon was well formed, as shown in Fig 8, but combined with the long extensor muscle belly, a condition very frequent in man. Heretofore this muscle has always been considered a possession of man only.

ADAPTATION OF THE HEEL FOR WEIGHT BEARING.

One of the first important and conspicuous alterations of the arboreal foot to be looked for in the adoption of terrestrial life with the erect attitude, is the adaptation of the heel for weight-bearing. In arboreal use, the heel rests lightly upon the supporting branch because the body weight is directed upon the fore part of the foot in order to increase the efficiency of the balancing grasp; by that means the center of gravity of the body is more readily controlled by the grasp. The apes, as well as the monkeys, have digitigrade rather than plantigrade feet. The naturally associated structure is a small or moderately developed posterior process of the os calcis. Such a condition in a terrestrial biped would mean that the foot, as a base on which to maintain balance, had no antero-posterior length except that furnished by the toes; consequently its stability would be dependent upon the strength of the flexor muscles and would be rendered insecure owing to the relatively free hyperextension of the toes. The gibbon presents a notable example of the manner in which terrestrial locomotion is performed under these conditions; it runs almost as erectly as man, but it always "runs'" to a desired point and then immediately squats. It does not walk or stand erect.

But the gibbon is an arboreal animal, while, in contrast, the precursors of man became permanent inhabitants of the ground. At first, in erect stance the body weight was thrown upon the fore part of the foot and equilibrium was maintained by a manual grasp on some nearby object; but, as only a slight, probably sub-conscious, backward shifting of the body's

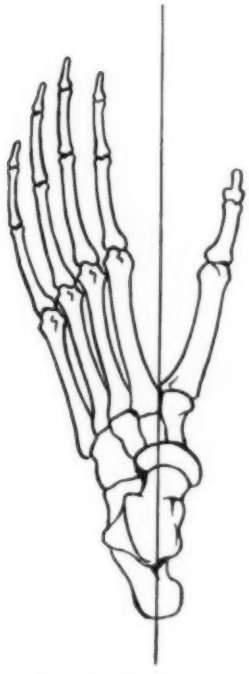

Fig. 9. Early pre-human foot modifications, (Hypothetical); shortening of the digits and metatarsals, increased stoutness of the first and second; developing heel.

center of gravity would cause the heel to come in firmer contact with the ground, and as thereby a secure base for antero-posterior balance would be obtained, it does not require a great stretch of the imagination to be convinced that the habitual use of the heel for facilitating erect stance was soon adopted. From this accomplishment to the use of slow locomotion—heel and toe walking—was a simple and easily acquired advance. The massive development of the heel in man and also in the gorilla, contrasts sharply with the moderate sized heel of the arboreal chimpanzee and the extremely small heel of the gibbon.

SUMMARY OF EARLY MODIFICATIONS.

The foregoing analyses show us how the anterior and the posterior pillars of the ultimate human longitudinal arch originated and the poten-

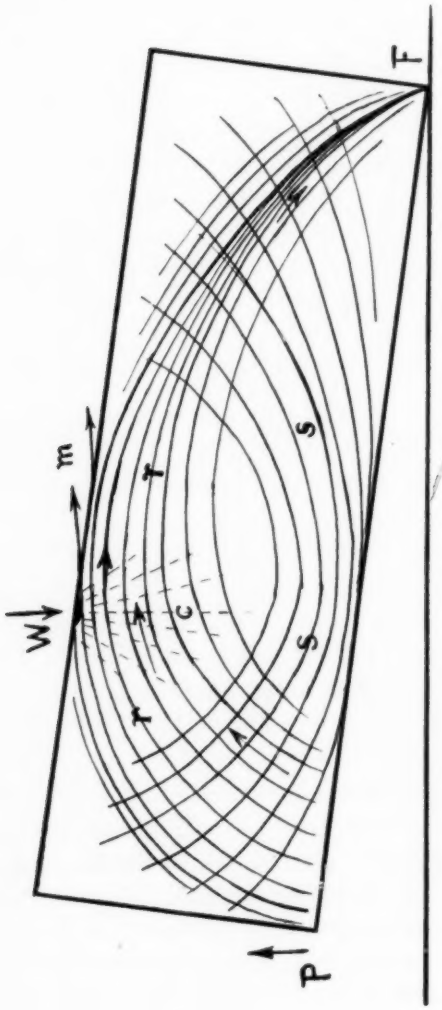

Fig. 10. Leverage, second class, as applied to a block. W, superimposed weight; P, lifting power; F, Fulcrum; Compression, c; Arc of leverage pressure, rr; Tensile strain, ss; Impetus, m.

tial development of the arch realized. Briefly summarized: the anterior pillar is traced back to the establishment of the humanoid line of leverage between the first and second metatarsal bones, which was created by the use of the balancing arboreal grasp: this line of leverage was retained in the adoption of terrestrial life by an irresistible shift of the body-weight upon the inner border of the foot, flattening the latter and completely over-

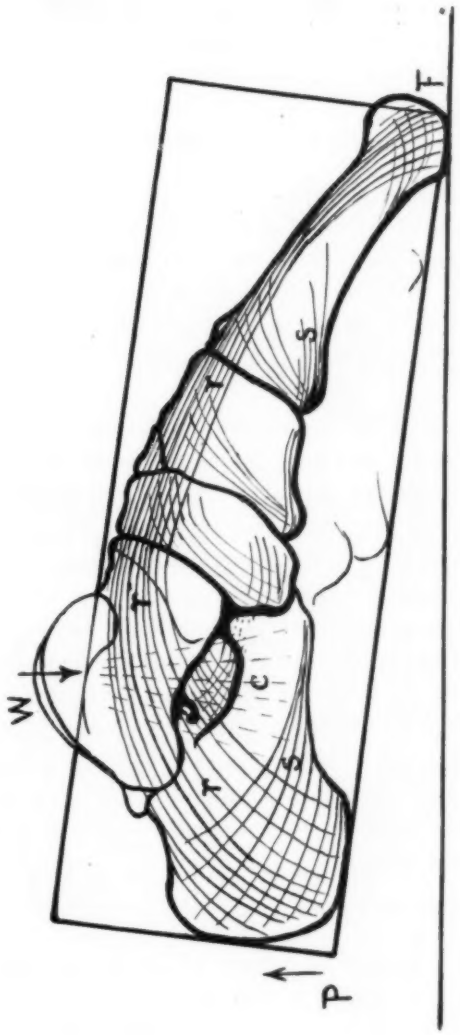

Fig. 11. The external contour of the inner border of the foot compared with the movements of force in the leverage block, as in Fig. 10.

coming the "supinated" posture; the posterior pillar originated as a weight-bearing structure by the employment of the erect posture on the ground. with a backward displacement of the center of gravity of the body, which threw the heel into firm contact with the ground, and thereby effected a secure base for antero-posterior stability of the body.

Fig. 9 shows an hypothetical pre-human foot in which the early terrestrial modifications are presented. Compare with the *Dryopithecus* foot, Fig. 7.

ELEVATION OF THE ARCH.

The longitudinally arched contour of the human foot is the result of specialization by leverage action on the ground. It may be considered that all other uses of the foot were discarded when man's ancestors descended from the tree and that this organ was yielded completely to the molding influences of this one single function. No other factors appear to obstruct or modify the straightforward course of changes toward its adaptation for this solitary purpose.

The modifications must be studied both in the vertical and in the horizontal plane. The primary and most prominent development occurs along the inner border, as it is in that area that the major movements of force are concentrated. Rather than attempt to follow blindly the evolutionary steps from a pre-human type to a modern specialized human foot, let us first analyze the modern structure and its mechanics in order to comprehend more clearly the progress which led to its present form.

There are three distinct processes which were instrumental in the modification of the arboreal foot and by which the elevation of the arch and elimination of unused arboreal characters were accomplished. They are: (a) the economical adaptation of the external and internal architecture of the bones to comply with the characteristic elements of leverage; (b) the correction of the faulty lines of the movements of force; and (c) an outward rotation of the os calcis.

LEVERAGE.

A block (Fig. 10) is used as a lever of the second class. Its lateral proportions correspond in height to that of the foot, and in length to the distance from the heel to the head of the first metatarsal bone. The corner F is the fulcrum, the lifting power is applied at P, and the weight is imposed at the point indicated by the arrow, W, which corresponds to the position of the center of the astragalus.

As soon as leverage action is instituted, if the stresses could be registered upon the block, they would follow certain lines or arcs, as indicated in the diagram. The first group are the lines of compression (c)

indicated by the broken lines, which radiate from the point of superimposed weight; the second group comprises those lines (r) which registered the upward thrust of the lifting power which curves upon the pressure area, and propels the pressure forward until it curves downward, converging upon the fulcrum; a third group are lines (s) which represent the reaction upon the tensile property of the block, or, in other words, lines of tension by which the tendency for the block to "break" opposite the position where weight is applied, is withstood.

The arc formed by the lines (r) from the lifting point to the pressure area is determined by the upward thrust and the amount of weight against which it acts, while the arc from the latter point to the fulcrum may be considered a trajectory arc. The movement of force indicated by the arrows above the block (m) indicates the transformation of pressure into impetus.

LEVERAGE AND THE HUMAN FOOT.

When we compare the lines on the side of the block as representing the separate mechanical elements of leverage, with the contour of the human arch (Fig. 11), it will be seen that there exists a remarkable similarity in conformation. This is carried out even more notably in the arrangement of the major trabecular systems. Those of compression (c) are best seen in the anterior portion of the os calcis; the second group (r) can be followed from the heel to the head of the metatarsal bone; the lines of the third group (s) for tensile strength are not complete. They appear prominently in the posterior process of the os calcis and can be followed from the lower margins of the bones in the fore part of the foot. The intervening portion is supplied by tough, non-elastic ligamentous material, the reason for which is obvious as, because of its extraordinary tensile strength and pliability, it makes possible the normal (although restricted) flexibility and resiliency of the human foot. If the joints between the small bones of the foot were bridged by a system of "tension" trabeculae, the foot would then become an absolutely rigid, osseous structure.

ECCENTRIC PRESSURE.

The foot, as a unit, displays the general architecture of an economically and efficiently built lever: it is not a single unit, however, but made up of numerous segments. Each one of these smaller individual units presents in itself the elements of a lever, but so modified as to conform with the phenomenon of "eccentric pressure" rather than of leverage.

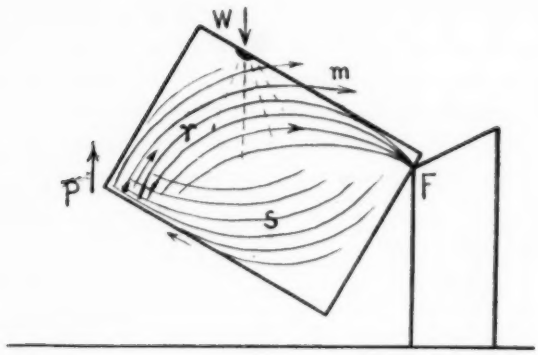

Fig. 12.

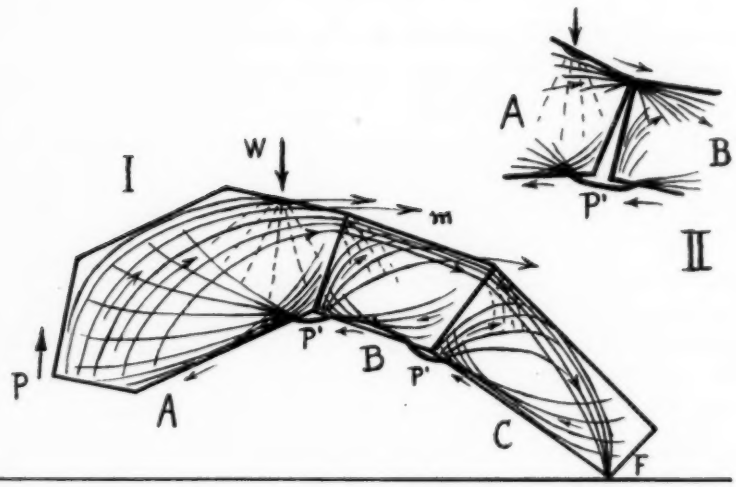

Fig. 13. Sketch I. Combined segments of eccentric pressure to give leverage. See text.

Sketch II. Showing tendency of blocks A and B to separate as a result of the upward pull at P.

This is shown in Fig. 12 where a single block, with weight superimposed, is lifted against another, but stationary, block. In this case the upper right hand corner is used as the fulcrum instead of the lower corner. The same lines of force (r, s, and m) are evident, but have a somewhat modified arrangement.

We may now consider the application of such modifications (Fig. 13).

Sketch I represents three blocks, A, B and C, irregularly shaped to conform diagrammatically to the segments of the foot.

In Block A the lifting power P′ furnishes the upward thrust, and at the same time tends to separate the lower adjacent corners of Blocks A and B, as indicated in Sketch II. The combined action causes the movements of pressure to converge toward the upper righthand corner of A (as in Fig. 12) whence it enters Block B.

In B the lifting Power P′ is furnished by the attachment to Block A, upon which the tensile lines (s) of A converge. Instead of weight being superimposed upon B, it enters the upper corner adjacent to A. The upward thrust from P′ and the tendency of the lower corners of B and C to separate (as previously in A and B) maintain the pressure lines (r) along the upper surface of B.

Block C shows a variation in that its lower righthand corner is the fulcrum for the movement of the combined structure, and upon it all the lines of force converge excepting those which have been projected (m) as indicated by the arrows.

The attachments P′ P′ represent interosseous ligaments in the foot, and which are reinforced by longer ligaments, the plantar fascia, and muscular action.

Now, as we turn again to Fig. 11, or, better still, refer to a lateral X-ray view of the foot, the reasons for the arrangements of the various trabecular systems will become apparent and their complexity less confusing.

EARLY LEVERAGE FUNCTION.

We have carried the development of the foot to a stage where terrestrial use had rendered the flexible arboreal structure flat, the line of leverage ran along the inner border, and the heel had been lowered to the ground. Leverage in a foot of that type was necessarily of a low order because it was unfitted for that purpose, owing to the slenderness of the bones and an insufficient supply of plantar ligamentous material. Any attempt to raise the bodyweight upon the metatarsal heads would cause a severe and possibly injurious strain. Furthermore, the larger calf muscles, gastrocnemius and soleus, were presumably weak at that time, if we may judge by the prevailing condition in modern apes. Early leverage action therefore was performed on a shortened anterior arm (Fig. 14), for the internal cuneiform bone, which had been forced downward in contact with the ground, acted as the primary fulcrum.

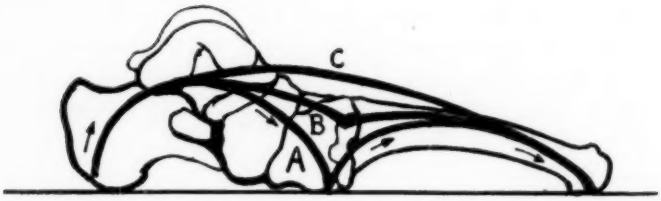

Fig. 14. Lateral view of arboreal foot on a flat surface (hallux removed to give better view). A, the early double arc due to contact of the cuneiform bone with the ground. B, the broken arc which indicates the direction of the line of movement of force when contact of the cuneiform bone with the ground is broken. C, the natural line which the forces of leverage would follow when the metatarsal heads act as a fulcrum.

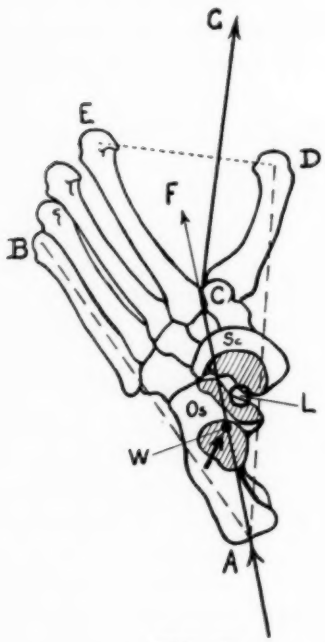

FIG. 15

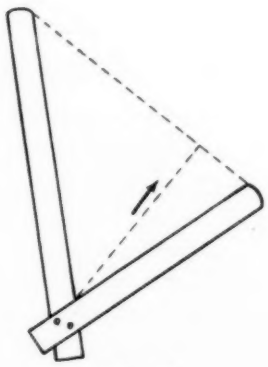

FIG. 16

Fig. 15. Dorsal view of chimpanzee foot. AB, outer line of support; AD, inner line of support; W, center of superimposed body-weight; L, lowest area in the calcaneo-scaphoid socket; C, inner cuneiform bone; Sc, scaphoid; Os, os calcis.

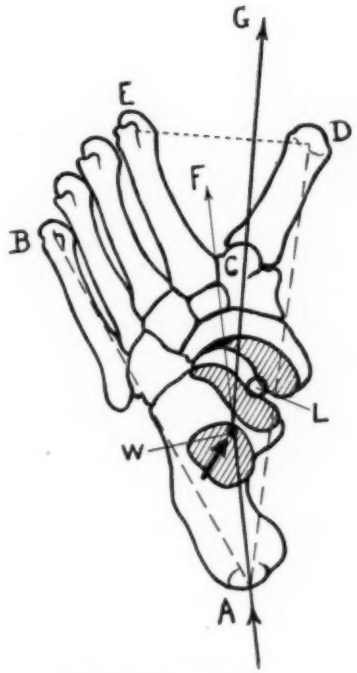

Fig. 17. Gorilla foot.

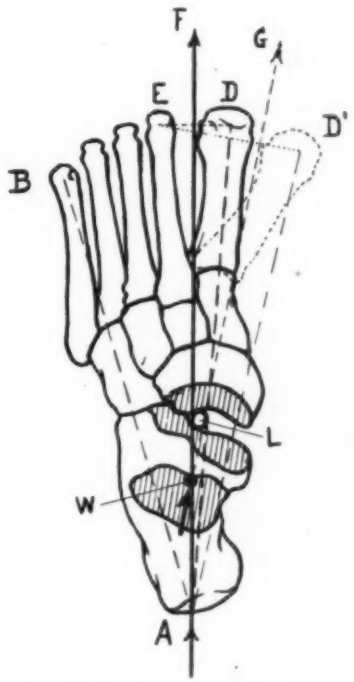

Fig. 19. Human foot.

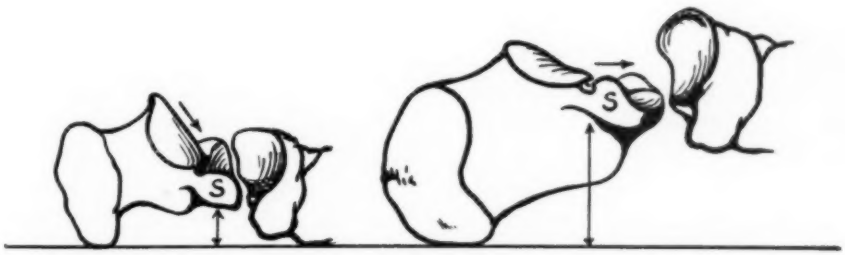

Fig. 18. Oblique posterior-inner lateral view of chimpanzee and human calcaneal and scaphoid bones, showing the respective positions of the sustentaculum tali (S), in the arboreal and human foot under superimposed weight. The arrows above the facets indicate the direction of their inclination which, in the arboreal foot, is abruptly downward and inward, and in the human foot more directly forward.

In terrestrial locomotion the body-weight was quickly shifted to the opposite foot in order to avoid an unnatural hyperextension of the metatarsal bones. The gait (in so far as leverage action is concerned) did not differ greatly from that of a person who has very flat feet; that is, locomotion was accomplished more by a shift of the body-weight from one foot to the other rather than by any forceful leverage effort of the feet.

INCREASED RIGIDITY OF THE FOOT.

The above statement does not mean that the leverage effort was of a negligible amount. These creatures were active and healthy, and rapidity of movement was one of the necessities of life; consequently, the demands upon the foot in regard to propulsive effort would certainly go apace with its utmost capability. The maximum of leverage function would frequently be utilized and the development of this function was steadily promoted. Continued strain upon the plantar ligamentous structures, but always kept subconsciously within the limits of safety, stimulated their development and strengthening so that hyper-extension became guarded against, and correspondingly more work fell upon the first and second metatarsal bones. Eventually, the increased plantar rigidity caused the fulcrum to be moved from the inner cuneiform bone to the heads of the first and second metatarsals. The results of this change, as it affected the mechanics of the foot, is shown in Fig. 14.

ALTERATION IN THE LEVERAGE ARC.

In the early flexible foot the arc of leverage followed the curve A in its posterior half, by which weight was transmitted to the ground through the inner cuneiform bone. This bone acted as the primary fulcrum. In the mild leverage effort which was performed by the metatarsals a fraction of the body-weight was lifted and was propelled in the metatarsal portion of that double arc. The second part of this action, weak at first, gradually became more important as the bones and ligaments developed in the manner described above. Ultimately the entire action was performed upon the metatarsal heads. Contact of the cuneiform bone with the ground was gradually broken and the lines of pressure followed the broken arc B. This movement of the forces was necessitated by the actual conformation of the bones, but the break in the arc B is incompatible with efficient leverage movement which would naturally follow the line C. The subsequent

development would be toward an adaptation of the structure to permit the movements of force to follow bony channels built in the line of C. Such alterations were promoted by stronger upward thrust from developing calf muscles more forcibly concentrating the movements of force toward the upper surface of the foot and by an associated outward roll of the os calcis, which will be considered later.

CORRECTIONS IN THE MOVEMENTS OF FORCE.

We may now turn from the changes which appear in the vertical plane to those which may be studied as we view the foot from above, using the chimpanzee foot (Fig. 15) to demonstrate the mechanics of early terrestrial function in the arboreal foot.

THE ARBOREAL FOOT.

When the arboreal primate foot is placed upon the ground its "supinated" posture causes the outer border A B to come in contact with the ground first. As body-weight is imposed the foot rolls inward because the center of weight W is located to the inner side of that line of contact. The depression of the inner border of the foot is exaggerated because of the abrupt inward and downward slope of the calcaneal facets which support the astragalus (See Fig. 18); their smooth, lubricated, and sharply inclined surfaces causes the astragalus to gravitate towards the lowest point L, in the socket formed by the sustentaculum tali and the scaphoid bone. The inward movement of the astragalus, carrying with it the weight of the body, has the effect of transferring the center of weight even further from the line A D than indicated by its actual position, thereby greatly increasing its crushing force, upon the inner border of the foot. The movement is not arrested until the inner cuneiform bone C which supports the scaphoid Sc, rests upon the ground. Contact of the metatarsal heads with the ground occurs about the same time.

In subsequent analyses, as the two points W and L play a very important part, their functional relationship should be thoroughly understood. The point W represents the location of the center of pressure as the body-weight enters the foot, but it is not the actual point from which weight is distributed to the different parts of the foot until the point L becomes thoroughly stabilized and supported. This is owing to the fact that the slope of the facets deflects the body-weight inwardly upon L, thereby causing the

latter (L) to become potentially the center of body-weight until counter-pressure through the scaphoid equalizes (through some extended contact with the ground as at C or D) the actual weight of the body. When the counter-pressure through the scaphoid becomes equal to the deflected weight, then the center of distribution of body-weight is returned to the point W. Because the point L lies practically on a line from A to C, some means of stabilizing the foot against the inward deflection of weight is necessary. This is accomplished by a divergence of the first metatarsal to D, so that the point L is located well within the line AD. Hence it is seen that even in terrestrial use of the arboreal ape type of foot a divergence of the hallux is requisite.

In the act of leverage, the lift of the heel throws the weight forward upon the fulcrum C, following the direction A F. This movement may be recognized as the one which forms the posterior or primary arc of leverage in the previous consideration of this phenomenon in its vertical plane.

Now we deal with a new complication. Two sticks, one longer than the other, are fastened together and laid upon a table (Fig. 16). The joined ends are raised upon the others as fulcra. The actual line of movement takes place in a plane perpendicular to the line connecting the fulcra, as indicated by the arrow.

In the arboreal chimpanzee foot the second metatarsal is longer than the first, a condition which prevails generally among the arboreal primates (this refers particularly to the more extended position of the head of the second.) As the secondary leverage effort is performed by these metatarsals, the movement cannot be made as a continuation of the line A F, but must follow the line C G which is perpendicular to the line D E connecting the heads of the first and second metatarsal bones which act as the fulcra. Here again we have a break in the line of the movements of force A C G, which is not consistent with efficient leverage action, but is conditioned by the unfitness of the arboreal foot for terrestrial usage. This fault naturally requires correction.

GORILLOID ALTERATIONS.

As we pass to the gorilla foot (Fig. 17) with its modifications, we find a distinct alteration in the mechanics. The calcaneal facets still present an abrupt inward slope as in the chimpanzee foot, so that the relationship of W to L is practically the same. It has probably been wondered why the hallux of the gorilla does not show some degree of permanently lessened

abduction since it has lived upon the ground long enough to create other terrestrial modifications. The position of the point L clearly shows that a continued abduction of the hallux has been necessary to furnish the proper relationship of the point L to the line A D in order to obtain lateral support.

The alteration in mechanics referred to above has been brought about by a lifting of the cuneiform bone C from contact with the ground so that leverage no longer is performed in that area but upon the metatarsal heads. When this action is instituted the lifting power at A tends to propel the weight in the direction A F, but as leverage movement must take place on the line perpendicular to the line D E between the two fulcra, the direction of movement must be altered to follow the line from the center of pressure towards G. Consequently, the gorilla foot also shows a break in the line of movement inconsistent with efficient leverage.

ROTATION OF THE OS CALCIS.

Before analyzing the mechanics as shown in the plan of the human foot, let us return to a brief comparison of the lateral views of the arboreal and human feet (Fig. 18). Here we find a marked difference in the respective positions of the sustentaculum tali (S) in the chimpanzee foot and in the foot of man. There is also a notable difference in the angle of inclination of the posterior process of the os calcis to the ground as the two types of feet are compared. The effect of the upward thrust from the stronger calf muscles of man lengthens the upward projection of its force and tends to shape the posterior process of the os calcis and its trabeculae accordingly.

The elevation of the anterior end of this bone during human development has been greatly helped by the concurrent action of the flexors after terrestrial habits had produced a reduction of the digits and an untwisting of the metatarsals. (By this means secure "fixation" points were furnished to the distal extremities of the flexor tendons by firm plantar contact of the digits with the ground; previously the laterally turned digits did not afford such fixation to the ends of the flexor muscles as was essential to their efficient bow-string action.) The flexors by pressing upward against the sustentaculum tali, not only raised the anterior portion of the os calcis, but also rotated it outward. The effect was naturally extended to the bones in front.

The important result was the altered position into which the calcaneal facets were thrown; their abrupt inward and downward slope became one which was essentially forward, downward, and only slightly inward; also the lowest point L in the calcaneo-scaphoid socket was moved toward the middle line of the foot.

THE HUMAN SPECIALIZATION.

Now, as we view the plan of the modern human foot, we see that the position of the point L is so located that it is supported by the line A D even when the first metatarsal is completely adducted; also the pitch of the calcaneal facets no longer throws the body pressure against the inner border of the foot, but almost directly in line with the long axis of the adducted first metatarsal bone. (Compare the direction of the short, heavy arrows on the posterior facets in Figs. 15, 17, and 19.) The lines of movement as determined (1) by point A and the center of weight, and (2) the perpendicular line from the center of weight W to the line D E, coincide in the single line A F. Consequently we find that in the modern human foot conditions have been acquired which by their complete conformation to engineering principles, are ideally adapted for support and also for propulsive leverage in the horizontal plane, as well as in the vertical plane.

ADDUCTION OF THE HALLUX.

Suppose the first metatarsal could assume an abducted position as indicated by the dotted outline D′ in Fig. 19. Such a position would undoubtedly add greater security to the balance of the foot because of the widened space between the point L and the line A D′; but the line of propulsive effort would become broken, presenting the same faulty mechanics that characterize the gorilla foot.

It is obvious that active, rather than passive function is the leading means whereby specialized modifications are produced, and if we recognize this as a fact, it then becomes apparent that the fixed adduction of the human hallux is as definitely the result of active leverage action as the elevation of the longitudinal arch, because by its fixed adduction in man, leverage efficiency has been increased by an economical reduction in passive lateral stability. With the gradual diminution of the abducted position of the hallux, the soft parts would naturally shorten and the lateral extension of the inner cuneiform facet which characterized the grasping foot, would

atrophy. A flattening of this facet would result as a modification to present a surface at right angles to the principal streams of force as the movement of the first metatarsal became more and more restricted.

OTHER DEVELOPMENTAL FEATURES.

INCREASED FUNCTION OF THE OUTER BORDER.

In the early terrestrial use of the arboreal foot, the greatest portion of work is thrown upon the inner border. As the elevation of this part gradually took place more weight was distributed toward the outer side of the foot, for the anterior end of the os calcis rested more directly upon the cuboid and the change in the slope of the calcaneal facets gradually ceased to direct body pressure so strongly inward. Gradually the outer border of the foot became a more actively functionating part. The mechanics of the modern human foot will be taken up in detail in a subsequent paper.

THE TRANSVERSE MID-TARSAL ARCH.

This arch in the arboreal foot forms a wide and flaring arc; in man it is contracted and greatly deepened toward the inner side. This development clearly coincides with our present analyses. In the arboreal foot the inner end of this arc points inwardly, but as we follow the evolutionary development of the human foot the major forces are concentrated upon the inner end of this arc, and they worked in a vertical plane; consequently, as the elevation of the inner border of the foot is increased by the action of these vertically working forces, the medial portion of the arc becomes bent, or rather developed, in the same vertical plane. The resulting deepening of the inner half of the transverse arch gives to the modern human foot its relatively slender dorsal aspect.

HEIGHT OF THE HUMAN ARCH.

There can be no absolute determination of a proper height for the human arch, because too many factors, even of physiological nature, act for or against increase of elevation. For example, there is no doubt but that an habitual or frequent use of a strong upward thrust at the heel, as in running, would tend to heighten that portion of the arch. In other words, any constant usage which exaggerates the action that was responsible for the original elevation of the arch would, to a certain degree, continue that effect.

The flexibility of the foot, however, due to its being composed of small units, has an opposing effect to that in the above observation. The slight movement of the separate bones on each other gives to the foot its resiliency and pliability but it also has a distinctly retarding effect upon the elevation of the arch. In contrast, shoe-wearing, particularly of closely fitted shoes which bind the foot, making it act more completely as a single unit for leverage, has a distinct tendency toward elevating the arch because it eliminates the retarding effect of the foot's natural flexibility. This seems to explain the greater prevalence of higher arches among members of the white races as compared to those which are not shoe-wearers.

The factors which could be brought up for consideration under this heading are too numerous to be dwelt upon in this paper.

PRONATION.

Because these studies have emphasized the importance of a certain feature which appears to explain the susceptibility of the human foot to this disorder, it may be permitted the writer to touch upon this subject.

In Fig. 19 the center of bodyweight W lies well between the two lateral lines of support, AD and AB. This is not the case in regard to the lowest point of gravitation L in the calcaneo-scaphoid socket. The latter point L is located very close to the inner line of support AD. Only a mild degree of pronation will cause the low point L to move inward across the line of support with an associated increase in the inward slope of the calcaneal facets. The resulting strain upon the inner lateral ligaments is magnified with each added degree of downward inclination of the inner border of these facets. They, the facets, act as frictionless inclined planes to reflect the body-weight laterally inward against weaker "controlling" ligaments of the side of the arch, and off the strong "supporting" plantar ligaments of the foot. Here is presented a phenomenon which is somewhat similar to the downward crush of the inner border of the arboreal foot in terrestrial usage, but the associated conditions are not the same. In the arboreal foot abduction of the hallux presents a means whereby support for this inflected weight can be restored, but in the human feet the fixed adduction of the hallux makes such a divergence impossible. Proper restoration of a normal balance in the human foot appears to depend primarily upon a return of the facets to a position in which they would present their normal forward, rather than a "faulty" lateral inclination.

Considering how slight a degree of inward rotation of the os calcis is necessary to disturb the thrust of the facets and the proper relationship of the point L to the line AD, the inner line of support, it is not strange that pronation is an extremely common disorder of the human foot.

RATE OF HUMAN ALTERATIONS.

The human modifications of the foot are most intimately tied up with the early history of man. According to the studies made by the writer, it would appear that the human branch alone, of all the offshoots from the parent great ape stem, adopted terrestrial life at a very early period. That the changes in the pre-human foot were quickly acquired is evident because of the fact that the body-weight is the most powerful mechanical force which continuously involves the skeletal structure; its molding influences became concentrated upon the feet thereby subjecting them to a more potent remodelling influence than any other part of the entire body structure. Since the erect posture is shown to be an extremely ancient character and an arboreal acquisition, it was common to the entire ancestral great ape group. Hence we may infer that the foot was the first bony structure to demonstrate distinctive terrestrial modifications that were peculiar to the developing human species. Hypertrophy of the heel, shortening of the digits and metatarsals, and an appreciable increase in the stoutness of the first and second metatarsal bones—characters of the more recently terrestrial gorilla—were possessions of man at a comparatively very early date. The development of human structural traits in other parts of the body followed slowly the alterations of the feet, because they were produced by less powerful and less constantly employed mechanical forces.

At first the changes in the feet were gross and coarse, and for this fact will be recognized as human modifications the more easily when we are fortunate enough to discover such ancient material. Even the foot bones of Neanderthal man who lived at a time that is very recent, compared with the period of man's origin, show a coarseness of structure which is far from the refined specialized contour of the modern human foot. Nevertheless, his foot is completely human.

We may conclude, then, that the development of terrestrial characteristics and the elimination of unused arboreal features progressed steadily in the human foot from the very beginning of man's terrestrial life.

CONCLUSION.

A review of this paper yields the following summary of conclusions:

1. Comparative analysis of the human, anthropoid, and other primate feet clearly indicates that the foot of man was evolved from a grasping, arboreal type such as is peculiar to the modern great apes. Furthermore, the great ape or gorilloid type of foot presents an intermediate stage in structural and functional modification through which, *of necessity*, the evolutionary development of the human foot had to pass.

2. The results of this analysis conform with other extensive evidence pointing out the close relationship of man and the great ape group, and makes more convincing the correctness of Darwin's conclusion in placing man's origin in the ancestral great ape stem.

3. The erect posture is an extremely ancient character, developed by arboreal life, and it had been fully acquired by the ancient anthropoid group as its natural arboreal posture earlier than the time of the separation of the human offshoot. The erect posture was retained by the early human representative as the *position of choice*, from the very beginning of his terrestrial life, because the previous arboreal use of it had become firmly established by structural adaptations and modifications of his nervous system.

4. The human foot is a specialized organ for leverage in bi-pedal locomotion. Its characteristic longitudinal arch conforms in its external contour and in its trabecular architecture to the direction of the movements of force in such leverage action, thereby demonstrating the process by which its form was evolved. The elevation of the arch was greatly aided by the bowstring action of the flexor muscles against the sustentaculum tali, in raising the inner side of the os calcis.

5. The longitudinal arch is absolutely not a modification of the previous supinated posture of the arboreal foot, for had that posture been retained the outer border of the foot would have become hypertrophied as the weight-bearing portion, and the inner border would have become atrophied because it had been held in an unusable position.

6. The position of the line of leverage between the first and second

metatarsal bones in the human foot is a distinct heritage from a previous grasping arboreal foot in which the movement of body-weight advanced between the two grasping portions, hallucial and outer digital. By such a previous grasping development the greater amount of function in weight-bearing was concentrated along the inner border of the foot and established conditions that were essential to the modification of this part to form the anterior pillar to the ultimate human arch.

7. The posterior pillar is the result of adaptation and hypertrophy of the os calcis for weight-bearing in association with the erect posture. It was entirely a terrestrial development.

8. Fixed adduction of the hallux in the developing human foot was acquired as lifting of the sustentaculum tali changed the abruptly inwardly inclined plane of the calcaneal facets (that characterizes the arboreal foot) to a plane which was more level and sloped more directly forward. The change in the position of the os calcis brought about the characteristic "balance" of the human foot and obviated the necessity of abduction of the hallux for inward lateral stability.

9. The position of the center of body pressure as it enters the human foot is not so important to foot balance as the degree of inward slope of the calcaneal facets which support the astragalus. The inward thrust of body-weight to overthrow the foot's normal balance is rapidly magnified with each degree of increased inward inclination of the plane of these facets.

10. Pronation, as a static disorder of the modern human foot, presents its particular danger in that the associated increased inward slope of the calcaneal facets cannot be counteracted upon by a divergence of the hallux as in the earlier developmental stages of the foot, because of the present fixed adduction of that member, and the added restricting action of shoes. Consequently, pronation creates a progressive vicious circle by which inward gravitation of body-weight depresses the inner border of the facets, which, in turn, by increased inclination magnifies the inward lateral thrust.

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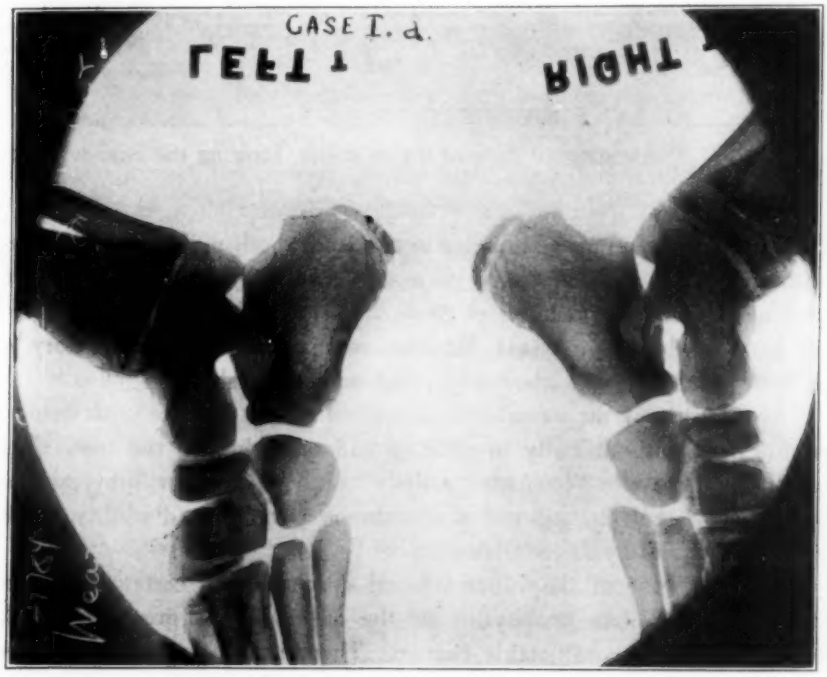
APOPHYSITIS OF THE OS CALCIS.

A Clinical Report.

BY NATHANIEL ALLISON, M. D., BOSTON.

I make this clinical report of two cases of so-called apophysitis of the os calcis because in observing the roentgenograms of the heels the bone changes were so exactly the counterpart of the changes noted by the roentgenogram in osteochondritis deformans juvenilis, (Legg's disease) that it seemed worthy of comment.

Heel apophysitis is supposed to be similar in its origin to the partial separation of the tibial tubercle described by Osgood. The fact that the pull of the strong thigh extensor is directly effective in one instance and



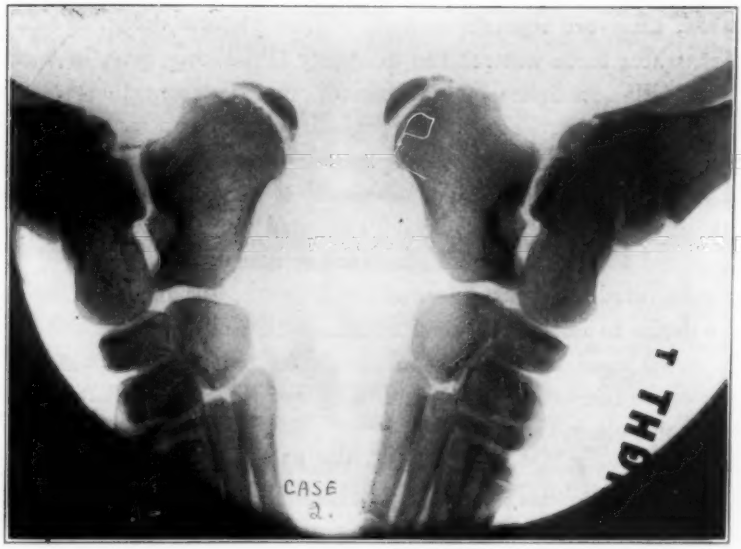
Case 1a. Lateral view of the heel in so-called apophysitis. The destructive changes and absorption of the epiphysis are evident.

Case 1b. Antro-posterior view of the os calcis, showing the change in the epiphysis.

of the strong calf group of muscles in the other, both pulling more or less constantly and at times violently, on a growing epiphyseal region, has been taken as sufficient explanation of both conditions. It is also well known that both of these epiphyseal disturbances may arise without history of strain or injury: that is, they may come on insidiously.

Apophysitis of the os calcis is described in the text books as being a painful heel, with difficulty in walking and on rising on the toes. It is stated that there is a "formative activity" of bone at the epiphyseal line. The disease is self-limited and results in no permanent disability or deformity.

Legg's disease of the upper femoral epiphysis has certain characteristics very similar to apophysitis of the os calcis. A growing cap-like epiphysis shows a considerable change. There is some pain and limping in both, and the disturbance is self-limited. In Legg's disease there is a resulting deformity, largely due to the anatomic location of the disturbance.



Case 2. A marked epiphyseal change very similar to the change of Legg's disease. Flattening, absorption, and segmentation of the epiphysis.

An analysis of the changes in the bone in a typical case of Legg's disease will show a flattening of the epiphysis, with a partial breaking up of the bone substance of the epiphysis, with also the development of numerous rounded punched out areas of bone absorption on the diaphyseal side. The epiphysis may be segmented; that is, divided into several parts by a process of absorption.

The cases of Legg's disease and apophysitis of the heel—and of Osgood's disease for that matter—all come on at a period of great activity in bone growth,—the seventh to the fourteenth year. In my own observation these affections are seen usually in rather stocky or heavy boys.

The cause of Legg's disease is not known: neither is the cause of so-called apophysitis of the heel. It is assumed that they are growth disturbances with some unexplained circulatory basis. Apophysitis of the heel has been explained by the mechanical pull of the gastrocnemious tendon on the heel epiphysis.

I have seen with my associate, Dr. Borden Veeder, in the last few months several cases of epiphyseal growth disturbance in active, healthy,

rapidly growing boys. The radiograms of the heels in two cases of typical apophysitis cases are reproduced here. These pictures, taken in two similar cases, where there was marked disability in walking, painful heels that were especially sensitive to the use of the gastrocnemious group of muscles, show a disturbance of the epiphyses exactly similar to the changes in Legg's disease. There is no evidence of "formative activity" of bone at all. The changes are those of a sub-chondral bone destruction. This picture, along with the fact that the boys affected were both of a heavy type, has prompted me to report the observations made.

Our knowledge of the abnormalities of growing bone is so incomplete and our desire to wall off clinical entities is so well fixed a habit of mind that it would seem advisable to check up on the possible existence of a common cause for some of the conditions that we now tabulate as distinct, one from the other.

Not sufficient time has elapsed to record the ultimate change that has established itself in these two sets of heels. It seems that there will result a very similar ultimate change to that seen as a end result in Legg's disease.

THE RESULTS OF TREATMENT FOLLOWING COMPOUND FRACTURES OCCURRING IN CIVIL LIFE.

BY ROBERT JAY COOK, M. D.

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When the surgeon of civil life is called upon to treat compound fractures the question arises as to whether they should be treated in the same manner as he was taught to treat those compound fractures which came under his care during the war, or whether the treatment which was in use prior to the war, or some modification of it, will give better results. He must decide as to (1) whether he will clean the field of the wound with antiseptics and then treat the wound by dressings intended to occlude infections aseptically; (2) whether he will drain the wound; (3) whether, after débridement, he will institute a course of Carrel-Dakin treatment; (4) whether he will débride and suture the wound immediately as in primary closure; or (5) whether he will do a delayed primary suture.

The treatment of potentially infected wounds in the war led to a gradual change in the methods of treating such wounds. At first the wounds were cleaned and treated aseptically, or with drainage, later the Carrel-Dakin method of treatment held sway for a time, and finally the method of choice came to be, when possible, immediate débridement with closure. Whether the surgeon will continue to employ débridement with closure or follow it by the method of Carrel-Dakin, or will again return to the treatment of these compound fractures by aseptic occlusion or by drainage tubes, using the Dakin solution to wash out the wound, (as he previously employed other solutions) is by no means settled. We find here and there a case lost or an infection passed beyond control under the use of either the Carrel-Dakin treatment or primary closure just as we formerly found, at times, when the wounds were treated by either the method of aseptic occlusion or by drainage. In such cases the surgeon is inclined to blame the method of treatment for the loss of the case. If he has employed the methods brought out during the war his natural tendency will be to think that he would have done better had he reverted to the older methods.

But before either condemning or supporting any one procedure it would be well to analyze a series of cases in civil life in all of which the

compound fracture occurred under approximately similar circumstances, and then to compare the results of the various types of treatment rather than to compare results obtained in treating wounds in civil life with those results obtained in treating compound fractures in army life, where the wound may be of an entirely different nature. It is not well to draw conclusions hastily nor to say dogmatically that because war wounds were treated by débridement with either Carrel-Dakin treatment or immediate suture those of civil life also should be so treated. The method of treatment under the two circumstances should perhaps differ. To determine the value of one method over another for use in civil life it would be best to review a series of cases taken from civil life and treated by the several methods of treatment in use. While the results of the treatment in war wounds are well known, the amount of foreign material and the possibility of infection varies somewhat in army and in civil life. It must further be kept in mind that the time elapsing between the accident and the treatment of wounds in army and in civil life differs greatly. In the war, surgeons often received these cases 10 or 12 hours after the receipt of injury, while in civil practice these injuries are usually received for treatment in from 1 to 4 hours after the injury, so that while the army surgeon may be chary about débriding and closing compound fractures, the civilian surgeon may not so feel.

With the idea of comparing the several methods of treating compound fractures I have looked up such cases as were treated in the New Haven Hospital since 1913 and have grouped them for comparison. From this grouping we may draw some conclusions as to the relative merits of the various forms of treatment.

The types of treatment may be grouped as follows:

a. Aseptic occlusion, in which the field of the wound was washed and cleaned, and the skin surrounding the wound treated with an antiseptic solution, such as bichlorid, alcohol, or iodine, and the wound swabbed with iodine and a sterile dressing applied.

b. Drainage, the field having been first cleaned and treated with antiseptic solutions, the wound was left open for drainage purposes.

c. The Carrel-Dakin technique.

d. Débridement with closure or with a small rubber tissue drain which was removed at the end of 24 hours.

In this survey I have attempted to study (1) the mortality under the several types of treatment; (2) the type of infection when known; (3) the

failure to débride or the incomplete débridement of the wound; (4) the failure to remove foreign bodies; (5) the effect of the introduction of foreign material into the wound; (6) as to whether proper treatment, i. e., reduction of the fracture could best be done primarily or had better be postponed until after the healing of the wound; (7) the occurrence of osteomyelitis in the different types of treatment; (8) bony deformity or shortening, mal-union or non-union; (9) the cause of failure in treatment; (10) subsequent alteration in treatment to meet emergencies arising; (11) the length of time required for the healing of the wound under the several types of treatment; (12) the percentage of success in the several types of treatment, and (13) the length of hospitalization.

From 1913 to 1923 we have had 116 cases of compound fracture of the long bones in the New Haven Hospital. Sixty-eight cases were treated primarily by the method of aseptic occlusion, 9 by drainage, 8 by the Carrel-Dakin method, 26 by débridement with closure of the wound, and 5 by immediate amputation.

ASEPTIC OCCLUSION.

Of the cases of aseptic occlusion, numbering 68, or 58.6% of the total, I find that 38 of the fractures were produced by direct violence and 25 by indirect violence, while in five cases it was uncertain as to whether the type of violence was direct or indirect. Thirty-one of these cases had a puncture wound over the site of fracture, while 37 had a lacerated wound. From a study of the case records we find that, in general, cases of indirect violence heal more rapidly than do those of direct violence, but the rapidity of healing depends also and to a greater degree on the type of wound, whether a puncture wound or a lacerated wound. Indeed, the wounds which were punctate healed in approximately the same time whether the force causing the fracture was direct or indirect, but when the wound was lacerated in character then those wounds which were caused by fractures of indirect violence healed in 90% of the time which was required for the healing of those wounds caused by direct violence.

In 20 cases the bone was protruding or exposed when the patient was examined, while in 48 cases the bone was covered by the overlying soft parts. When the bone was exposed,—either protruding or having retracted but still lying exposed,—the time for healing of the wound was twice as long as when the bone was not exposed. This statement refers only to those cases in which the wound healed with no subsequent treatment other

than the usual aseptic dressings. Of the cases that healed by this method primarily (if we neglect the factor of whether the bone was exposed or not) we find that it required 10% more time for healing in those cases in which the injury was caused by direct trauma than in those caused by indirect violence.

In this group the following bones were fractured: the humerus in 6 cases; the bones of the forearm in 9; the femur in 10; and the bones of the lower leg in 48 cases, the latter being the commonest site of fracture.

Of the 68 cases, 46 fractures were reduced immediately, while 22 fractures were reduced at a subsequent operation, 11 being reduced by the closed method and 9 by the open method. The wound over the fracture healed in approximately two-thirds of the time in those fractures which were reduced immediately as in those reduced subsequently. When compound fractures were reduced by wiring or plating through the open wound, i.e., before the wound had healed, it required six times as long for healing to be completed as in those cases where no foreign material was introduced within the wound. The infection engendered and the sequestra formed are the probable responsible agents for the delay in healing. On the other hand, in those cases in which the wound was permitted to heal first and then, following the healing, a reduction of the fracture by open operation was attempted, the time required for healing was, when averaged, but twice the normal time.

Sixteen cases required drainage subsequently, 5 more cases required that the wound be more widely incised for drainage, while 2 required a sequestrectomy, and in 4 cases Carrel-Dakin treatment was used.

Amputation was performed in 3 cases, one because of extensive destruction of the soft parts, one on account of infection and osteomyelitis, and one because of osteomyelitis alone.

In most of these cases the organisms invading the wound were not known because cultures of the wounds were not taken, but in one streptococcus was found (in this case the wound healed after being further incised and drained), and in three others staphylococcus was found.

Of those cases in which the wound healed without complication the average time required was 62 days. In other cases secondary operations were performed for drainage, for osteomyelitis, for removal of wire or plates introduced into the infected field, or for sequestra. In these latter cases we find the healing long delayed because of the infection around the

plate or wire or because of the delay in removal of the sequestra. After the removal of the sequestra or foreign body the healing of the wound occurred fairly rapidly.

In this group of cases there were 9 deaths, 13%. Three died on the day of admission, one the day following admission, from the effects of their injury, one from pneumonia on the third day, one on the operating table under nitrous oxid anesthesia while the leg was being incised and drained because of a gas bacillus infection, two of septicemia on the eighth and fifty-sixth days respectively, and one died on the seventy-eighth day having had throughout his stay in the hospital the diagnosis of dementia paralytica and delirium tremens.

DRAINAGE.

There were 9 cases in which drainage was instituted on admission. Of these, 3 received their injury by direct violence and 6 by indirect. There was a puncture wound over the site of fracture in 3 cases and a lacerated wound in 6. The fracture was exposed or protruding in 6 cases but not exposed in 3.

Of the bones fractured, one was the humerus, one the radius and ulna, two the femur, and five the bones of the lower leg, the tibia and fibula. The fractures were reduced immediately in 6 cases.

In this group of cases it is difficult (owing to the small number of cases) to reach a definite conclusion as to the time of healing when compared with the type of injury and the kind of wound. However, we do find in those fractures which were immediately reduced that the time of healing was somewhat shorter than in those not immediately reduced.

Three cases required subsequently more extensive drainage; in one case amputation was required because of gas bacillus infection; and in four cases a sequestrectomy was required.

The average time required for the healing of the wound in these cases was 117 days.

There was bony union in 5 cases, mal-union in 1 case, and non-union in another.

Death occurred in 1 case, and that on the day of admission.

CARREL-DAKIN TREATMENT.

In this group of 8 cases the wound was first débrided and then treated by the Carrel-Dakin technique. Of these cases, 5 received their injury by

direct violence, and 3 by indirect violence. Every case in the group had a lacerated wound over the site of fracture when admitted.

The bone was exposed or projecting on examination in 7 cases but was covered in 1.

There was one fracture of the bones of the forearm, one of the femur, and six of the tibia and fibula.

One patient died the day following admission, leaving 7 cases to be treated by the Carrel-Dakin technique.

In one case it was subsequently necessary to enlarge the wound to increase the drainage; and in two a subsequent sequestrectomy was necessary.

The fracture was reduced immediately in 5 cases; in 1 on the day following admission; and in the 2 remaining cases on the fourth and eleventh days respectively. Four of the above cases were again reduced as follows: (1) by plating, after healing; (2) realigning before healing with uneventful recovery; (3) suture of the bone fragments with closure (this wound had to be reopened the following day on account of streptococcus infection); and (4) wiring of the fracture on the sixth day. (In this case the wound had not healed on the forty-eighth day, when the patient was discharged.)

Amputation was done in one case because of the inability to control hemorrhage; in this case the gas bacillus was also present in the wound.

The organisms isolated by culture were staphylococcus in one case, streptococci in two cases, and gas bacillus in one case.

Under the Carrel-Dakin treatment the wounds healed in four cases in an average time of 130 days. Two wounds were not healed on discharge —an average time of 65 days. In the case in which the limb was amputated the stump had healed on the eighty-third day.

The Carrel-Dakin treatment was also used in four cases which had been primarily treated by the method of aseptic occlusion. In the first case it was started on the sixth day; however, the wound was not healed on discharge on the thirty-third day. In the second case it was employed on the eleventh day; the wound had not healed on the seventy-fourth day. In the third case it was introduced on the seventh day and the wound was not healed on the one hundred and seventy-sixth day. In the fourth case it was used on the ninth day following a secondary open reduction in which the wound had been healed for 14 days prior to the operation. This wound healed in 28 days following its use.

In the cases treated primarily by débridement and suture the Carrel-

Dakin treatment was also used in four cases. In the first case the wound was opened on the second day following closure because of a streptococcus infection, the wound was more widely incised and drained on the fourteenth day, Dakin treatment was begun on the twentieth day and the wound was healed on the thirty-fourth day. In the second case the wound was drained on the twenty-ninth day, further incised and drained on the ninety-second day, Dakin treatment introduced on the ninety-sixth day, and the wound healed on the one hundred and seventeenth day. This wound was also infected by the streptococcus. The third case was drained on the second day, Dakin treatment instituted on the ninth, the wound opened more widely on the tenth, a sequestrum and devitalized muscle were removed on the thirteenth, the fracture was wired on the thirty-first, re-wired on the fifty-second day, and the patient was discharged with the wound healing on the seventy-fifth day. Staphylococci and B. coli were cultured from this wound. The fourth case was drained on the second, Dakin treatment started on the fourth day, the wound was healed on the thirty-ninth day, the fracture was plated on the forty-second day, the plate removed on the seventy-eighth day, and the wound was healed on the eighty-seventh day.

DEBRIDEMENT AND IMMEDIATE SUTURE.

In this group there are 26 cases. Of these, 23 received their fracture by direct violence and 3 by indirect. There was a puncture wound over the site of fracture in 11 cases, while in 15 cases there was a lacerated wound.

The bone was exposed in 6 but not exposed in 20 cases.

Of the bones fractured, the humerus was involved in three cases, the radius and ulna in seven, the femur in two, and the tibia and fibula in fourteen.

Bone fragments were removed in four cases; and, also, foreign bodies were removed in four cases. In the cases where bone fragments were removed, two healed promptly in 16 to 20 days respectively. One case was Dakinized after being twice drained—it healed in 117 days. The other case in which bone fragments and a foreign body were removed during débridement was one in which the fracture was sutured with kangaroo tendon. The soft parts over and around the fracture were badly lacerated and were incompletely débrided. This case developed a gas bacillus infection and died.

Of the three cases in which a foreign body was removed, one healed

in 20 days, another was not healed on discharge the fourth day, and the last case was re-drained on the fifth day, sequestred on the seventy-fourth day, and healed on the eighty-first day.

In 21 cases the fracture was reduced primarily; 13 healed in an average time of 35 days; 3 were not healed on discharge which took place under 12 days; and 5 had to be re-drained and then healed. Of the 5 cases in which the fracture was not reduced, one died the day following admission with thrombosis, one had a gas bacillus infection and the leg was later amputated, one was re-drained several times as it had not been completely débrided at the primary operation. Of the two remaining cases, one fracture was sutured on the twenty-second day, primary healing having preceded the operation, and the course of healing completed on the one hundred and twelfth day, was uneventful. The other fracture was plated after primary healing but the wound became infected and was drained, final healing taking place on the ninety-fourth day.

AMPUTATION.

Five cases were amputated on admission, the blood-vessels being severed in two cases, and the limb being so extensively injured in the other three that amputation was necessary.

In connection with those cases treated primarily by aseptic occlusion, amputation was performed three times, one because of the extensive laceration of the soft parts, and two because of extensive osteomyelitis of the tibia.

In one case treated by drainage in which aseptic solutions had been used but in which no débridement had been done, though the wound was extensively lacerated, a gas bacillus infection developed and amputation was found necessary.

In one case treated by the Carrel-Dakin method, amputation was performed because of extensive hemorrhage and gas bacillus infection.

Amputation was done in two cases treated by débridement and suture. In one of these, in which the soft parts were badly lacerated and incompletely débrided but the wound closed, the fracture having been sutured by kangaroo tendon, gas bacillus infection developed and it became necessary to amputate the arm. In the other case a gun-shot wound was incompletely débrided both as to the excision of devitalized muscle and the débriding of

the track of the bullet, and the removal of the bullet. Gas bacillus infection developed and the leg was amputated.

Death occurred in nine cases treated by the method of aseptic occlusion as follows: three on the day of admission and one on the day following admission from the effects of injuries, one on the third day from pneumonia, one on the operating table under nitrous oxid anesthesia while the leg was being drained for gas bacillus infection, two of septicemia, one on the eighth day and the other on the fifth-sixth, one case having delirium tremens and also dementia paralytica, on the seventy-eighth day.

Of the cases treated by drainage one death occurred on the day of admission.

In those treated by the Carrel-Dakin method there was one death on the day following admission.

Of the cases treated by débridement two died—one of thrombosis on the day following admission, and one of streptococcus and gas bacillus infection due to the incomplete débridement of the wound as cited above.

SUMMARY AND CONCLUSIONS.

Death occurred in three cases treated by the method of aseptic occlusion: two of septicemia and one of a gas bacillus infection. Under this method a leg was amputated in two cases for chronic osteomyelitis.

In the cases treated by drainage gas bacillus infection developed in one case and the leg was amputated.

In the cases treated by the Carrel-Dakin method it was necessary to amputate a limb in which gas bacillus infection was present.

In the cases treated by débridement and suture two cases, both of which were completely débrided, died from a gas bacillus infection, and in two cases of gas bacillus infection it was necessary to amputate a limb.

When wounds are found to be infected by the streptococcus it is necessary to open the wound widely and desirable to treat the wound by the Carrel-Dakin method.

When a gas bacillus infection is present, amputation above the level of the infection should be done.

The failure to débride or the incomplete débridement of a wound has given opportunity in several cases for the development of gas bacillus infection, and in other cases has given rise to infection delaying the time of healing of the wound, osteomyelitis has frequently developed,—in a few cases so pronounced that amputation has been done,—and sequestra have also formed delaying the healing of the wound. When débridement is well done these infections should not occur. The failure to remove foreign material has, in some cases, made it necessary to amputate the limb or has caused death. For this reason there has been a delay in healing of the wound because of infection.

When it is possible to reduce the fracture at the time of the primary treatment it is found that the wound heals much more quickly. Contraindications were found in cases where the circulation was endangered, where there was danger of increasing the infection from the handling which such a procedure at times entails, or where it was difficult to keep the fracture reduced. When the fracture cannot be maintained in reduction by the replacement of the fractured ends in apposition it is better to wait and to do an open reduction after the primary wound has healed. The introduction of foreign material, such as tendon, wire, or plates, into the wound has led to difficulty and the development of a gas bacillus infection because of which amputation was later necessary.

Osteomyelitis is more common in those cases treated by aseptic occlusion, drainage, and incomplete débridement.

Bony deformity, as shortening of the limb, may occur in any type of treatment where it is not possible to maintain proper traction or to suture, wire plate, or graft the fracture when indicated. Non-union occurs most commonly because of the presence of infection, as does also a delayed union. Non-union and delayed union are also affected by the presence of lues.

The causes of the failure of treatment in cases treated by aseptic occlusion were incomplete drainage, infection, osteomyelitis, and sequestra. In simple drainage we find, likewise, the same causes of failure, with the additional one of the introduction of plates and wire. The main difficulty or cause of failure when the Carrel-Dakin treatment was used was the presence of sequestra or osteomyelitis. In the cases treated by débridement and

suture the failures were due to incomplete débridement, as evidenced by the subsequent infection.

When any form of treatment has failed it has been necessary to redrain the wound, to remove sequestra or osteomyelitic bone, and in the more serious cases of gas bacillus infection to amputate. The Carrel-Dakin treatment has been of much value in keeping the infection of wounds under control when the focus of infection has first been removed.

In the cases of débridement and primary suture treated successfully, the time of healing averaged 22 days; in those cases treated successfully by aseptic occlusion the wounds were healed in an average time of 62 days; those cases which healed following drainage with no subsequent operation did so on an average of 117 days; the cases treated by the Carrel-Dakin method healed in an average of 130 days.

Wounds of compound fractures caused by direct violence heal, in general, more slowly than do those caused by indirect violence, because the traumatization of soft parts in the latter case is not as severe. However, this distinction is complicated by the fact that the extent of trauma and laceration of the wound has a marked relation to the time of healing required. It is possible, moreover, to require the necessary time of healing by débridement of the wound. In this series of cases we find that débridement reduces, by one-half, the time required for the healing of lacerated wounds if we compare the lacerated wound treatment by aseptic occlusion and débridement. Puncture wounds treated by aseptic occlusion healed in about the same time as wounds treated by débridement.

The time which the patient must spend in the hospital is shortest under the method of débridement and suture, when successfully done. Next in order, in respect to time, is the method of primary occlusion, and next, the Carrel-Dakin technique.

68 Cases Treated Primarily by Aseptic Occlusion.

A. D. No. 69,313. White boy, aged 9 years. On November 8, 1918, he was struck by a motorcycle and received a compound fracture of the right tibia. He was admitted to the hospital on the same date, where the puncture wound was cleaned, swabbed with iodine, and dressed. He was placed on a posterior Cabot splint. On December 12, the wound was healed. He was discharged with the leg in a cast on December 21, at which time there was firm bony union, no shortening being present. The wound had healed in 34 days, the patient was discharged in 43 days from admission.

J. S. No. 69,436. White male, aged 37 years. The patient was struck by an automobile on November 17, 1918, and received a compound comminuted fracture of the left tibia, with a puncture wound. The wound was cleaned, swabbed with iodine, and dressed. Buck's extension was placed on the leg. The wound was healed on December 3. On this day a cast was applied to the leg and he was discharged on December 19. On removal of the cast December 30, there was bony union, and the left leg was 0.5 cm. shorter than the right. The wound had healed on the 16th day, and the patient was discharged on the 32nd day.

L. B. No. 69,883. White boy, aged 5 years. He received a compound fracture of the left tibia when he was struck by an automobile on December 19, 1919. On admission there was present a puncture wound, the diameter of which was 1 cm. This was cleaned and dressed, and the limb was placed in a posterior Cabot splint. Two days later the leg was placed in a cast and the patient was discharged on December 24. The wound was not healed, but the fractured bone was in good position. The patient left the hospital on the 5th day following the accident, the wound not being healed on this date.

A. B. No. 70,669. White boy, aged 7 years. The patient was struck by an automobile on February 26, 1919. When examined on admission to the New Haven Hospital, a compound fracture of the right tibia with a puncture wound 1 by 2 cm. just over the fracture was found. The wound was cleaned and dressed, and the leg placed in a posterior Cabot splint. The leg was placed in a cast on March 1. The wound was healed on March 15. The patient was discharged on March 21, the fracture having united with no shortening. The wound had healed in 21 days, and the stay of the patient in the hospital was 23 days.

M. S. No. 71,241. White girl, aged 10 years. In falling on a sidewalk she received a compound fracture of the right radius with a simple fracture of the right ulna. On admission, April 19, 1919 (the day of the accident), a puncture wound was found over the fracture; the wound was cleaned, swabbed with iodine, dressed, and the arm placed in an anterior and posterior splint, wet dressings being later applied. The fracture was reduced on April 23, under ether. The wound healed on

May 6, and the patient was discharged with bony union on May 30. The wound had healed in 17 days, and the patient left the hospital in 43 days.

H. McC. No. 72,066. White male, aged 29 years. The patient was admitted to the New Haven Hospital on July 7, 1919. He had received a compound fracture of the left radius and ulna. In the accident room a puncture wound overlying the fracture was cleaned, swabbed with iodine, and dressed, and the arm splinted. He was discharged two days later in care of his family physician, the fracture being in good position and the wound in good condition.

N. S. No. 73,746. White boy, aged 12 years. The patient fell during a basketball game and received a compound fracture of the right ulna. A puncture wound of 1 cm. diameter was over the site of fracture. The patient was admitted on the day of the accident, November 28, 1919. The wound was cleaned, swabbed with iodine, and the forearm placed on a splint. The patient was discharged on December 2, having been in the hospital four days. The fracture was in good position, the laceration was clean, and the arm was still splinted.

B. D. U. No. 51,433. White man, aged 59 years. On July 31, 1914, the date of admission, he was struck by a trolley car. He was found to have a compound fracture of the right femur, 5 inches above the lower end, and with this a large puncture wound of the skin 2 inches above the line of fracture; the bone was not projecting when examined. The wound was cleaned and dressed and he was treated with a Buck's extension; later the limb was placed in an extension splint with suspension. The wound was healed in 14 days. On September 4, the extension was removed and a cast applied. The cast was removed on October 17. There was firm bony union with 1.5 cm. of shortening. He was discharged on October 24 as cured, 85 days after receipt of injury.

M. D. No. 49,660. White boy, aged 11 years. The patient fell 10 feet on May 2, 1914, receiving a compound fracture of the right humerus, with a puncture wound of the skin. Wound was cleaned, swabbed with iodine, and dressed. Patient was discharged May 15, wound healed, bones in satisfactory position. The wound had healed on the 13th day, the date of discharge.

D. E. No. 55,054. White woman, aged 58 years. On October 1, 1915, the date of admission, she fell downstairs, receiving a compound fracture of the left radius and ulna. On admission, the puncture wounds were cleaned, swabbed with iodine, the fractures reduced, the wounds dressed, and the arm splinted. The patient was discharged October 29, with the wounds healed and bony union. The duration of her stay in the hospital was 28 days.

A. G. A. No. 55,941. White male, aged 30 years. He had received a gunshot wound of the thigh resulting in a shattering of the middle

third of the right femur on December 24, 1915, the day of admission. On admission the leg was cleaned, shaved, and the wounds of entrance and exit of the bullet enlarged and swabbed with iodine, and dressed. The leg was placed on a posterior Cabot splint, and on December 26th, Buck's extension was applied. The recovery was uneventful; the wound had healed on January 24, and the patient was discharged on February 25, 1916, it being noted that he had strong fibrous union. The wound healed on the 31st day, and the patient was discharged on the 63rd day.

W. D. No. 57,268. Negro male, aged 41 years. He received a gunshot wound and a compound fracture of the left radius on April 21, 1916. On admission the same day the wounds were cleaned, swabbed with iodine, and dressed. There was a wound of entrance and another of exit for the bullet. He was discharged on April 27 with an unhealed wound but with the bones in good position. Remained in the hospital for 6 days.

A. B. No. 58,839. White male, aged 36 years. The patient was admitted August 22, 1916, a weight of 25 lbs. having fallen on the left forearm. He was found to have sustained a compound fracture of the ulna. The soft parts over the fracture were lacerated. The wound was cleaned, swabbed with iodine, and placed in a splint. He was discharged August 25, the 3rd day, the wound not healed but the bones in good position.

C. R. No. 64,056. White woman, aged 59 years, was in an automobile accident in which both femurs and both tibias and fibulas were broken, the left femur being compounded and comminuted. The accident occurred on October 27, 1917, the date of admission to the hospital. The wounds were cleansed and swabbed with iodine and sterile dressings applied. The legs were elevated and extension applied. The wound over the compound fracture healed in 3 weeks. She was placed in a cast on December 19. The bony union of the femur was fair on January 20, 1918. She began to walk on February 10, and was discharged on March 26 with the fracture firmly united and the right leg 2 inches shorter than the left. The wound over the compound fracture had healed in 21 days. The patient was discharged on the 150th day.

O. F. No. 65,631. White male, aged 46 years. The patient was admitted on March 16, 1918, on which day a barrel weighing 300 lbs. had fallen on his left leg. There was a compound comminuted fracture of the left tibia with a lacerated wound and a simple fracture of the fibula. The wound was cleaned and dressed and a posterior Cabot splint applied. March 25 the leg was put in a plaster cast, both legs on this date being of equal length. The cast was removed on April 29, and the wound was found to have healed. On May 7 the patient was discharged walking with crutches. There was bony union with 1 cm. of shortening. The wound had healed in 44 days, and the patient was in the hospital 52 days.

W. W. No. 67,317. White man, aged 23 years. He was admitted July 21, 1918, the motorcycle upon which he was riding having collided with an automobile. He received a compound fracture of the right tibia and a simple fracture of the fibula. The puncture wound was cleaned and dressed and a posterior Cabot splint applied. The fracture was reduced on July 25, and again on August 5. The wound was healed except for a sinus on August 27. He was discharged on August 28, there being bony union, but further dressings being necessary. The patient was in the hospital 38 days, the wound not being healed on discharge.

S. C. No. 63,710. White male, aged 8 years. He was admitted on September 26, 1917, having sustained a compound fracture of the left femur by a fall from a window. A small puncture wound was found over the site of fracture. This was swabbed with iodine and dressed, and the patient placed in bed with overhead extension. The wound healed by October 23. He was discharged on December 6 with good bony union and 1 cm. of shortening. The wound healed on the 28th day, and the patient was discharged from the hospital on the 72nd day.

G. R. No. 63,002. White woman, aged 50 years. On July 31, 1917, she was struck by the running board of a trolley car and received a compound fracture of the right tibia and fibula. There was a lacerated wound over the site of fracture, which was cleaned and dressed. The leg was placed on a posterior Cabot splint and the wound was treated with wet bichlorid compresses 1-10000. On August 6 she was discharged under the care of her family physician, the wound showing no evidence of infection. The wound was healing well on the 6th day when she was discharged from the hospital.

J. R. No. 62,865. White male, aged 21 years. On July 20, 1917, patient was struck by an automobile while riding a motorcycle. He received a compound fracture of left tibia and a simple fracture of fibula, a small puncture wound being over site of fracture. The wound was dressed the same day, and the leg placed in a Cabot splint. The fracture was reduced July 27. The wound was healed August 13, and a cast was applied. August 31 patient was discharged with the bone united, there being no shortening. The wound was healed on the 24th day, and the patient was discharged from the hospital on the 42nd day.

B. H. No. 62,451. White male, aged 48 years. On June 19, 1917, he was struck by a train and received a compound fracture of the humerus. The wound was cleaned and dressed on admission. It healed by July 17, and the patient was discharged on August 9. There was bony union but no shortening. The wound had healed in 28 days, and the patient was discharged on the 51st day.

H. D. No. 62,379. White boy, aged 5 years. He was admitted on June 6, 1917, having been run over by an automobile. He received a

compound fracture of the left tibia. In the accident room the puncture wound was cleaned with soap and water, bichlorid, saline, iodine, and dressed, and the leg was placed on a posterior Cabot splint. On June 19, the wound being clean, the leg was put in a cast. The wound was healed on June 30. Measurements taken July 30 gave no shortening. He was discharged August 25, walking without crutches, with firm bony union. The wound had healed in 24 days, and the patient was discharged on the 80th day.

L. R. No. 61,817. White man, aged 36 years. He was admitted to the New Haven Hospital on May 5, 1917. He had been kicked by a horse and had sustained a compound fracture of the left tibia. Over the site of fracture there was a puncture wound 1 cm. in diameter. On admission the wound was cleaned, swabbed with iodine, and dressed. On May 26, the wound having healed, the leg was placed in a cast. There was bony union at this time. The patient was discharged in a cast on June 1, 1917. There was no shortening of the leg. The wound had healed in 21 days, the patient was in the hospital 26 days.

W. D. No. 60,151. White boy, aged 13 years. On December 10, 1916, he was run over by the wheel of a wagon and received a compound fracture of the right tibia. There was a lacerated wound over the site of fracture. The wound was cleaned, swabbed with iodine, and dressed in the accident room. The wound healed by February 1, 1917, and the patient was discharged on February 28, 1917, with the wound healed and with firm bony union, and with no shortening. The wound healed in 44 days, and the patient was discharged from the hospital in 71 days.

R. G. No. 59,628. White man, aged 19 years. He received a gunshot wound on November 5, 1916, and with it a compound fracture of left fibula. The wound was cleaned, swabbed with iodine, and dressed. By the 30th of November, the wound had healed. The patient refused operation for removal of bullet, and was discharged on December 10, walking. The wound had healed on the 25th day, and the patient was discharged on the 35th day following the accident.

A. G. No. 73,467. White male, aged 21 years. The patient was admitted on November 4, 1919, following a motorcycle accident. He had received a compound fracture of the right tibia, the laceration over the fracture measuring 1 by 2 cm. The wound was cleaned and dressed in the accident room, the leg placed in a posterior Cabot splint, and the patient sent to the ward. The wound drained until November 13, on which day the leg was placed in a cast. The patient was discharged on November 18, 14 days from date of accident, the laceration being practically healed and the fractured bone being in good position.

T. Z. No. 61,715. White male, aged 39 years. On April 28, 1917, the date of admission, he fell downstairs, receiving a compound fracture of left tibia, and a comminuted fracture of the fibula. The bone was

exposed in its middle third. The wound was cleaned and dressed, and leg placed on a posterior Cabot splint. On May 1, the fracture was reduced and placed in a cast, a window being cut over the wound for draining. The bone remained exposed to May 18, on which date the patient was discharged wearing a cast, the wound not having healed in 21 days, the duration of his stay in the hospital.

K. L. No. 62,014. White girl, aged 5 years. She was knocked down by a motorcycle on May 18, 1917, and was admitted to the hospital the same day. On examination a compound fracture of the left femur with the bone protruding was found; the left leg was 2.5 cm. shorter than the right. The wound was swabbed with iodine, the fracture reduced, and a dressing applied, the leg being treated by extension. The child was taken home against advice 2 days later.

C.V. No. 63,079. White male, aged 44 years. His right leg was caught between a falling tree and a sharp stone on August 7, 1917, and he received a compound comminuted fracture of the right tibia. At examination there was found a lacerated wound over the fracture. The wound was cleaned and swabbed with iodine, several loose pieces of bone were removed, and a clean dressing applied. The wound was allowed to heal in by granulation. On August 30, the bone was still exposed but by September 28 the bone was covered by granulation and there was bony union. The right leg was 1.5 cm. shorter at this time. On November 1, 1917, when discharged, he was able to bear weight on the leg though still using crutches. The granulating wound had not epithelialized. The patient remained in the hospital 86 days but the wound had not epithelialized in this time.

W. F. No. 67,613. White male, aged 21 years. He was in a collision of motorcycles on August 16, 1918, and received a compound fracture of the right tibia and fibula. On admission the bone was exposed. The site of the wound was cleaned and dressed and the leg splinted. August 20, the fracture was reduced and the leg put in a plaster cast. At dressing the following day there was some pus in the wound. By September 6 there was a clean granulating wound and on September 10 an open reduction of the fracture was done, at which time one bone end was successfully notched into the other. There was firm bony union one month later, and the wound had healed on October 26. He was discharged with no shortening on December 19, with bony union but wearing a brace. The wound had healed in 71 days and the patient was discharged on the 125th day following the injury.

C. A. No. 52,180. White female, aged 26 years. Admitted to the hospital on November 4, 1914. An automobile in which she was riding overturned and the patient received a compound fracture of the left tibia. On admission there was an open wound 2 inches square exposing the fracture. The wound was cleaned, swabbed with iodine, dressed, and the leg was placed on a posterior Cabot splint. The fracture was

reduced on the following day, redressed, and the leg placed in a cast. A window was cut from the cast so that the wound might be dressed with alcohol compresses. By January 19, 1915, the date of discharge, bony union had taken place, but the wound had not yet healed. The patient was in the hospital 76 days.

Z. F. No. 58,652. White male, aged 22 years. On August 5, 1916, patient was in an automobile accident and received a compound fracture of the left tibia. When the leg was examined the same day, the bone was found to be exposed. The wound was cleaned and dressed, and the leg placed in overhead suspension. By September 6 granulation tissue had covered the bone. There was bony union by October 26. The patient was walking unassisted on discharge, January 28, 1917, though the wound was not healed. The duration of hospital treatment was 176 days.

J. M. No. 58,799. White male, aged 22 years. The patient was admitted August 18, 1916. On this day, in a factory accident, he received a compound fracture of the left radius and a simple fracture of the ulna; the bone was projecting. The wound 1½ inches by ¾ inch, was cleaned and dressed, and the arm placed in a splint. The fracture was reduced on the 19th, and again on the 24th of August. The patient was discharged September 9, with the wound granulating and the alignment of the fractured bones improved, The patient was discharged from the hospital on the 22nd day.

J. B. No. 59,287. White male, aged 35 years. He was admitted October 4, 1919. The patient had fallen 20 feet, and had received a compound fracture of the right tibia and fibula. On admission the bones were found protruding; the protruding ends were trimmed off, several fragments removed, the wound cleaned, and wet dressings applied. The leg was placed on a posterior Cabot splint. The wound had healed by November 21, and there was firm bony union. On December 20 the patient was discharged, healed, with bony union, and 1.5 cm. shortening. The wound had healed on the 48th day; the patient was discharged on the 77th day.

T. B. No. 59,749. White male, aged 50 years. The patient was admitted November 15, 1916. A piece of iron fell on his leg, giving him a compound fracture of the right tibia. On admission the bone was found to be exposed through a long lacerated wound. The wound was cleaned, swabbed with iodine, dressed, and a splint applied. The fracture was reduced 2 days later, under anesthesia, and the leg placed in a Cabot splint. Extension was placed on the leg November 29. The wound had healed January 7, 1917. There was bony union January 23. On February 1, the leg was placed in a cast which was removed on the 21st. The patient was discharged, cured, February 22, the wound having healed in 53 days, and the patient having been in the hospital 78 days.

E. J. No. 55,813. White male, aged 58 years. On December 11, 1915, he fell from a ladder and sustained a compound fracture of the right tibia and a comminuted fracture of the fibula. On admission the same day, under anesthesia the field of the wound was scrubbed, the wound irrigated with H_2O_2, and all bleeding points ligated, several loose bone particles removed, and the wound dressed. The leg was placed on a posterior Cabot splint. On December 14, a cast was applied to the leg. The wound was healed and there was bony union by February 9, 1916. The patient was discharged on March 4. In this case the wound healed on the 60th day and the patient was discharged from the hospital on the 83rd day.

R. T. No. 54,313. White man, aged 30 years. He was admitted on July 26, 1915 (the date of injury) with a compound comminuted fracture of the right femur at the junction of the middle and lower thirds; the bone was not protruding. The external wound, which had a diameter of 2 cm., was cleaned, swabbed with iodine, a loose fragment removed, and a cast applied—all under ether. The wound healed by August 13. The patient was discharged with bony union on October 14, his stay in the hospital having been of 80 days' duration, though the wound healed in 18 days.

P. D. N. No. 55,565. White male, aged 24 years. Patient was admitted November 15, 1915, having been injured by a freight train. He had received a compound fracture of the right tibia and fibula, and a simple fracture of the left tibia. The lacerated wound of the right leg was cleaned and dressed on admission and the legs put on posterior Cabot splints. Buck's extension was applied to the left leg on December 5, and to the right on the 11th. It became necessary to incise and drain the right leg on December 13. The right leg did not heal entirely until May 5. The patient was discharged on May 6 with bony union. The right leg was 3 cm. shorter than the left. The patient was in the hospital 172 days; the wound healed on the 171st day.

G. K. No. 67,926. White boy, aged 16 years. On August 22, 1918, he fell 20 feet from a cable wire, receiving a compound comminuted fracture of the left radius. On the same day the puncture wound of the forearm was cleaned and dressed, the fracture reduced, and the arm splinted. On September 5 it became necessary to open the wound because of infection. On September 8 there was pain in the axilla with enlargement of the axillary glands, and a reddening of the skin of the lower arm. This proved to be erysipelas. The patient was discharged on September 21, having recovered from the erysipelas but with the wound not healed, though there was bony union. Flexion of the elbow was normal but extension was limited at 165 degrees. The patient was under treatment 30 days, the wound not having epithelialized on discharge.

B. R. No. 58,497. A white male, aged 30 years, was struck by an

automobile on July 22, 1916, and received a compound comminuted fracture of the left femur. The fracture was at the junction of the middle and lower thirds of the femur, and over it was an opening 1½ inches on the inner aspect of the thigh. The wound was swabbed with iodine and dressed. The leg was placed in Buck's extension. The wound healed over by granulation, but on August 30 pus was liberated through the granulations and a probe was passed between the broken ends of the bone; the bone was not united and there was infection. The wound was therefore incised and drained and the leg put in a plaster cast. The wound was again probed on September 9 and Penrose drains inserted. On December 31, a plaster spica was applied. The wound was healed on March 15, 1917. Bony union was fair, and there were 15 degrees of motion at the knee. The patient was discharged on March 20, 1917. The wound had healed in 236 days, the patient being discharged on the 241st day.

L. R. No. 67,261. White boy, aged 16 years. The patient was struck by an iron girder and received a compound fracture of the left tibia on July 18, 1918. On admission, the same day, there was a wound over the site of fracture which was cleaned, swabbed with iodine, and dressed. On the following day the wound was opened wider, many loose fragments of the tibia were removed, the wound was irrigated with peroxid and saline and packed with gauze. On July 24 Dakin's tubes were inserted because of some pus, but were removed on August 6, the wound being clean. He was discharged on August 20. The wound had granulated well, there was no infection, and bony union was present. The wound was not healed on discharge, the 33rd day.

F. S. No. 63,730. White boy, aged 8 years. The patient was admitted September 27, 1917. He had caught his leg in the spokes of a wheel, and had received a compound fracture of the left tibia and fibula. On this date the wound was cleaned and dressed and the leg placed in a pillow splint. There was a large denuded area over the fracture. The wound healed by December 10. On December 24 the fracture of the tibia was reduced by open operation and the position of the bone corrected; a plaster cast was applied. On January 2, 1918, pus came from the operative wound, and Carrel-Dakin treatment was started. January 9, the purulent discharge had stopped, and there was bony union. On the 21st, the cast was removed, the wound was healed, and union was firm. Patient was discharged February 22, walking. There was 0.5 cm. shortening of this leg. The wound had healed in 74 days and the patient was in the hospital 148 days.

C. K. No. 64,715. White woman, aged 55 years. The patient fell down a hole in a sidewalk on December 22, 1917, and was admitted the same day. The left tibia was fractured and compounded. There was a puncture wound 2 cm. in diameter. The wound was cleaned, swabbed with iodine, and dressed, and the leg splinted. On January 2, 1918, there was considerable pus coming from the sinus leading down to the

tibia, the tibia being at this time exposed for a distance of 3 cm. Carrel-Dakin treatment was instituted. January 5, at operation, the wound was incised for purposes of drainage, Carrel-Dakin treatment being continued. February 9 a small granulating sinus still existed. The patient was discharged on March 6, the wound being covered with granulations but not epithelialized. The alignment of the fractured bone was not satisfactory, though the bone was united. There was 2 cm. of shortening. The patient was in the hospital 74 days, being discharged with the wound not healed.

H. A. No. 2369. White male, aged 20 years. The patient was admitted on July 24, 1921. He had been struck by an automobile and had sustained a compound fracture of the left tibia and fibula. On examination there was found a deep laceration over the site of fracture. This field was cleaned, swabbed with iodine, and dressed, and the leg placed in a posterior Cabot splint. August 1, the wound was widely incised, bony fragments and necrotic tissues were removed and Dakin tubes inserted. On August 12 the fracture was reduced, and again on August 29, Carrel-Dakin treatment being continued. During the period between August 10 and August 29, sequestra were removed. On November 17, it was found that the wound had healed, and on November 23, sequestrectomy was again performed, and Dakin tubes again inserted. By January 16, the wound had healed and the bones had united. The patient was discharged on February 11, bony union having taken place. The wound healed in 176 days and the patient was discharged on the 202nd day.

A. P. No. 58,394. White male, aged 20 years. The patient was struck by a falling chimney on July 14, 1916. He received compound fractures of the right humerus and of the left tibia and fibula. He was admitted on the day of the accident. The lacerated wounds of the arm and leg were cleaned and dressed; the arm was placed in extension splint and the leg in a posterior Cabot splint. The wound in the arm drained for two months and then healed in by granulation,—it being healed on November 12. The leg wound drained for three months, at which time a sequestrum was removed; another sequestrum was removed on December 12, after which the wound granulated until he was discharged on January 30, 1917. On discharge the fracture was healed. The arm wound healed on the 121st day, that of the leg on the 200th, the day of discharge.

E. P. No. 1,585. White male, aged 51 years. Admitted on May 12, 1921, on which date he had been struck by an automobile. He was found to have a compound fracture of the right tibia and fibula with a lacerated wound overlying the fracture. The wound was cleaned and dressed. Cultures taken from the wound showed staphylococci. The wound healed by June 12. On June 21, an open reduction of the fracture was done and kangaroo tendon was employed to unite the fractured ends. July 9, the wound was healed, and on July 16 the

fractured bone was found in good alignment. The patient was discharged on the 65th day, the wound having healed on the 31st day.

J. M. No. 54,726. White male, aged 46 years. The patient was admitted August 31, 1915. He had that day fallen from a loaded wagon, the wheel of which had passed over his leg, and had sustained a compound comminuted fracture of the left tibia and fibula. The laceration was cleaned and dressed, and the leg placed in a fracture box. On September 17, at operation, a Lane plate was placed on the tibia and a cast applied. Sutures were removed on September 27. The wound was healed on October 18. The patient was discharged on December 11, with the plate in place and with bony union. The wound had healed in 48 days and there was no shortening. He was discharged on the 89th day.

K. S. No. 48,570. White boy, aged 14 years. The patient was admitted to the N. H. H. October 31, 1913. He had been struck by an automobile and had sustained a compound fracture of the right tibia and a simple fracture of the fibula. He was treated in the accident room the same day, and was admitted to the ward after the wound had been cleaned and disinfected with bichloride 1-10000. On November 4, a Lane plate was placed on the tibia, the wound was closed, and a cigarette drain was placed in the puncture wound received at the time of injury. The operative wound had healed p. p. on November 13, but a sinus later developed in the operative scar. This sinus tract was cut out and the plate removed on January 15, 1914, the wound being packed with iodoform gauze. The patient was discharged on February 13, 1914, with bony union, but with the wound still draining, 105 days after the accident. The blood count at no time was over 13000 W. B. C. and 84% polys.

D. B. No. 55,503. White man, aged 64 years. The patient fell from a wagon on November 10, 1915, receiving a compound, comminuted fracture of right tibia. On admission, the same day, the wound was cleaned and dressed. On November 16, the leg was incised, a piece of bone was removed, and a Lane plate was used to unite the fracture. The skin was closed. On November 26, the dressings were found to be purulent. On December 8, the skin about the incision sloughed and the plate was exposed. On December 22, the plate was covered by granulation. On January 25, 1916, the plate was removed; there was no bony union so the bone ends were drilled in several places and the wound packed with gauze. The leg was placed on a posterior Cabot splint. The patient was discharged February 5, 1916; the wound had not healed, nor had the fracture united. The patient was in the hospital 87 days.

S. C. No. 60,120. White man, aged 49 years. Patient was admitted on December 16, 1916, with a compound fracture of the left tibia, having been thrown against a pile of iron by a switch engine. The tibia

was fractured in two places; one at the junction of the middle and upper thirds, and the other 5 inches below, both being compound fractures. The wounds over the fractures were lacerated. They were cleaned and dressed on admission, but not sutured. On December 30, a Steinmann pin was placed through the os calcis for traction, but was removed on January 3, 1917, and the leg was put in a plaster cast with a window cut out over the fracture and its sinus. On February 17, the bone was still protruding, but had become granulated over by March 10; at this time the bones were wired, and the wires subsequently removed on April 25. The patient was discharged on June 24, 1917, 190 days after admission, with shortening of 3 cm. The bones were covered by granulation tissue and the fracture was united, the wound not epithelialized.

H. B. No. 59,178. White male, aged 22 years. The patient was admitted September 27, 1916. While riding a motorcycle he collided with an automobile, receiving a compound fracture of left tibia and fibula. On admission, the same day, the wound was cleaned and dressed. The leg was amputated on October 3, because of tissue destruction, but the stump did not heal. The stump was reamputated on January 5, 1917. He was discharged February 11, with the stump not healed, having been in the hospital 137 days.

I. C. No. 55,083. White girl, aged 11 years. On October 5, 1915, she was struck by an automobile, receiving a compound fracture of the left tibia and fibula. The wound was cleaned and dressed in the accident room, and the leg splinted. On October 23, the fracture was wired and set. On October 27, there was some infection, which was irrigated with H_2O_2. By November 27, union had not taken place. On February 18, 1916, it was necessary to incise and drain the leg. On March 16, there was marked periostitis of the left tibia. On June 12, the leg had healed except for a sinus. On July 17, there was marked osteomyelitis of the shaft of the tibia. On July 19, the leg was amputated through the lower end of the femur. The patient was discharged, cured, September 28, 1916. The stump was healed on the day of discharge, 359 days after admission.

M. C. No. 70,441. White male, aged 41 years. The patient was knocked down and dragged by a train on February 4, 1919. On examination at the New Haven Hospital, the patient was in shock and was found to have a compound fracture of the right tibia and fibula, the bones being exposed. The wound was cleaned, a small portion of the right tibia removed, the wound swabbed with iodine, and dressed. Staphylococcus aureus was cultured from the wound on February 6. The leg was placed in a posterior Cabot splint. On February 12, because of infection, the leg was incised further and wound opened more widely. On March 6, because of osteomyelitis of the tibia at the site of fracture the leg was amputated, the amputation being done through the middle of the tibia. Following the amputation the wound was

Dakinized. The patient was discharged on May 7, the stump having healed except for a superficial ulcer. The stump was not healed on the 92nd day, when the patient was discharged.

E. C. No. 49,609. White boy, aged 10 years. He was struck by an automobile on May 10, 1914. Examination on admission showed a compound fracture of both the right and left femur. The wounds were cleaned and dressed and the legs immobilized. Death occurred a few minutes later.

M. D. No. 65,966. White male, aged 26 years. On April 8, 1918, the patient was caught by an air-ship propeller and received a compound fracture of the left tibia and fibula (the wound gaping widely), and a simple fracture of the humerus. When admitted he was suffering from shock. The wounds were cleaned and dressed, and the legs were put on posterior Cabot splints, and the arm on an angular splint. He died the evening of the same day.

M. P. No. 57,028. White girl, aged 4 years. The patient was admitted March 30, 1916, having been struck by a truck, receiving a compound fracture of the left humerus. The laceration over fracture was cleaned and dressed. Death occurred the same day.

C. T. No. 68,127. White male, aged 32 years. The patient was in a trolley car accident on September 26, 1918, and received a compound fracture of right tibia. On admission, the same day, there was found a puncture wound over the site of fracture, which was cleaned and dressed, and the leg placed on a posterior Cabot splint. Death occurred on September 27, 1918, the patient not recovering from the effects of the accident.

L. A. No. 1,268. White male, aged 25 years. The patient was struck by a street car and received a compound fracture of the left femur (middle third) on April 15, 1921. He was admitted immediately after the injury, but because of shock the wound was only cleaned and a sterile dressing placed thereon and the leg splinted. He died on April 18, the third day, of pneumonia.

W. H. No. 59,768. White male, aged 29 years. He was admitted November 17, 1916. On this date, in an automobile accident, he received a compound comminuted fracture of the right tibia; the bone was exposed through a long laceration. The wound was cleaned and irrigated, swabbed with iodine, dressed, and the leg placed on a splint. On the 19th, there was crepitus on the external surface of the leg, but cultures from the wound were negative. Because of probable gas bacillus infection, however, the leg was drained by several long incisions. Nitrous oxid anesthesia was used. The patient died on the operating table.

R. B. No. 58,980. White male, aged 26 years. He was admitted September 4, 1916. While riding a motorcycle he collided with an

automobile, receiving a compound fracture of left tibia and fibula. There was a lacerated wound over the fracture. The wound was cleaned and dressed on September 4. The patient died September 12, the 8th day, of septicemia.

J. R. No. 66,697. White man, aged 62 years. The patient received a compound fracture of right radius while cranking a car. He was admitted on June 4, 1918, the day of the accident. There was a puncture wound over the site of fracture. The wound was treated by wet dressings. The fracture was reduced on June 5. The forearm was incised on June 13, and cultures taken from the pus showed staphylococcus. The patient died on July 30 of general septicemia, 56 days after the receipt of injury.

W. S. No. 52,233. White male, aged 56 years. On January 1, 1914, the patient slipped on the street and sustained a compound comminuted fracture of the left tibia. On admission to the hospital the same day, the puncture wound overlying the fracture was cleaned and an alcohol dressing applied to the wound. The wound granulated over, and on January 22, 1915, the fracture was plated with a Lane plate. It became necessary to remove the stitches 5 days later because of pus, although the plate was left in until March 3. The patient had a positive Wassermann and an aortic aneurysm. He had delirium tremens while in the hospital and was also diagnosed dementia paralytica. Death occurred on the 78th day following admission, the wound not having healed.

A. P. No. 50,597. White girl, aged 5 years. On June 7, 1914, patient fell downstairs and received a compound fracture of the right humerus. The wound was cleansed in the accident room with soap and water, ether and bichlorid 1-10000, and dressed. On the following day the skin was closed with sutures, a rubber tissue drain being inserted. On June 14, the stitches were partly removed on account of pus. The wound had healed by July 5. On July 11, passive motion of the elbow was done under anesthesia, and the patient was discharged on August 2, 1914, with the fracture united and the wound healed. The wound healed in 28 days, and the patient was discharged on the 56th day.

L. F. No. 51,832. White male, aged 24 years. The patient was admitted on November 20, 1914. He had been kicked by a horse and had sustained a compound fracture of the right tibia, a lacerated wound 1½ inches by ½ inch overlying the fracture. The bone was exposed. The wound was cleansed with alcohol and ether, and swabbed with iodine. The leg was then placed in a cast. He was discharged on December 9, the wound being healed, the fracture having united with no shortening.

A. T. No. 51,573. White male, aged 22 years. On November 5, 1914, the patient was struck by an engine and sustained a compound,

comminuted fracture of the right tibia. The wound was cleaned, swabbed with iodine, and dressed with alcohol sponges, and the leg placed in a cast on admission. The patient was discharged 4 days later, the bone being in good alignment, and the wound clean.

W. C. No. 51,615. White male, aged 20 years. The patient was admitted on October 22, 1914. He had been run over by an automobile and had received a compound fracture of the left tibia. On admission the wound overlying the fracture was cleaned, swabbed with iodine, and dressed. The fracture was reduced the following day, and a cast applied. The patient was discharged on November 13, 1914, with the leg in a cast. The wound healed in 12 days, and the patient was discharged on the 21st day.

S. K. No. 59,193. White boy, aged 11 years. The patient was run over by a truck on September 25, 1916. When admitted, the patient was found to have a compound fracture of the right femur, with a puncture wound over the site of fracture. The bone was not exposed. The wound was cleaned and dressed. The leg was treated by extension with suspension. On October 10, the femur was refractured and reset with improvement in the length and alignment. The bone had united on November 16. The patient was discharged on November 29, with the leg in a splint. There was ½ inch shortening. The wound had healed in 15 days, and the patient was discharged in 25 days.

M. D. No. 49,660. White boy, aged 11 years. The patient fell 10 feet on May 2, 1914, receiving a compound fracture of the right humerus, with a puncture wound of the skin. The wound was cleaned, swabbed with iodine, and dressed. The patient was discharged May 15, the wound healed, bones in satisfactory position. The wound had healed on the 13th day, the date of discharge.

9 Cases Treated Primarily by Drainage.

B. L. No. 56,305. White male, aged 31 years. The patient fell from a window, a distance of one storey. He was admitted on January 25, 1916, the date of the accident. Examination showed him to have a compound fracture of the left tibia and fibula, with laceration over the site of fracture, and a comminuted fracture of the right tibia and fibula. The fractures were reduced under ether, the wound was drained with eight rubber tubes, the wound not being closed. Posterior Cabot splints were applied. On March 17, there was bony union of both legs, the position of the fractured bones being excellent. The patient was discharged on March 26, the lacerations being healed. The total time in the hospital was 60 days.

H. S. No. 52,773. White male, aged 50 years. The patient fell from ladder on May 20, 1914, receiving a compound fracture of left tibia. On examination a puncture wound 2 cm. in diameter was found over the site of fracture. On admission the wound was cleaned and a 1-10000

bichlorid compress placed on the wound. June 3, an open reduction of the fracture was done; on June 11, there was suppuration from the wound; on July 11, wound was granulating in; on October 1 and 7, small sequestra were removed; on October 12, there was bone union. The wound did not heal until March 28, 1915, the date of discharge, at which time there was firm bony union, with no shortening of the leg. The patient was discharged from the hospital 312 days after admission.

C. P. No. 73,919. White male, aged 41 years. The patient was struck by an automobile while riding a bicycle. When admitted on December 15, 1919, examination showed a compound fracture of the left tibia and fibula with a lacerated wound over the fracture. The wound was cleaned, swabbed with iodine, and packed with gauze. The leg was placed in a pillow splint. On December 19, the wound was dressed and packed with iodoform gauze. Staphylococcus aureus was cultured from the wound. On December 22, extension was applied to the leg. On January 20, 1920, the leg was put up in plaster. On January 26, the patient was discharged. The wound was not healed but the bone fracture was in good position. The patient was readmitted on March 3, 1920. Examination revealed an ulcerated area 0.5 cm. over the tibia, the tibia was exposed, and the fractured bone was not united. On March 8, a sequestrectomy was done. The wound was closed, and the leg placed on a posterior Cabot splint; on April 2, a cast was applied; on April 6, there was a slight callus formation, but the wound was still discharging; on April 26, the wound was healed, and the patient was discharged. There was a false point of motion at the line of fracture. The wound was healed on the 132nd day, when the patient left the hospital.

A. L. No. 55,925. White man, aged 43 years. He was admitted with a compound fracture of the tibia, on December 23, 1915. On examination the bone was found protruding. The wound was dressed in the accident room, and on the following day the leg was operated upon and drainage established. On December 28, because of increase in the amount of pus discharged, the leg was placed in a permanganate bath. On December 29, the local incisions were enlarged and the thigh was drained, Penrose drain being inserted in the incisions of both the lower and upper leg. On January 21, 1916, both incisions were enlarged to obtain better drainage. He was discharged on March 5, with an osteomyelitis of the tibia, the bone protruding, 72 days after injury. There was, however, bony union.

M. M. No. 70,335. White man, aged 29 years. The left forearm of the patient was caught in the wheel of a machine and he received a compound fracture of the radius and ulna, with a gaping wound. On admission to the New Haven Hospital the day of the injury, January 23, 1919, the wound was cleaned and opened widely; the patient was sent to the ward and the arm placed in 2% B. A. bath. The wound

healed by granulation on March 14. The patient was discharged on March 24, with bony union and overriding of 5 cm., the fracture bones being in poor position, but the function of the hand being satisfactory. The time of healing was 50 days; the period in the hospital 61 days.

E. L. F. No. 66,989. White boy, aged 11 years. The patient fell 20 feet from a tree on June 27, 1918, receiving a compound fracture of the left humerus, the bone protruding. The wound was cleaned the same day with green soap and water, bichlorid and peroxid, and two Penrose drains inserted. The wound healed September 20, at which time he was discharged, being advised to re-enter the hospital in 2 months for correction of deformity, there being malunion. Stay in hospital 85 days.

L. H. No. 56,696. White male, aged 24 years. The patient was admitted March 1, 1916. On this day his foot was caught in a wheel and he received compound fractures of the right tibia and fibula. There were small lacerated wounds over the site of fracture. The wounds were cleaned on admission, swabbed with iodine, Penrose drains inserted, and the leg placed on a posterior Cabot splint. On March 2, there was subcutaneous emphysema; on March 3, at 1 A. M., the lower leg was incised and drained; at 7 P. M., the same date, the leg was amputated through the lower third of the thigh because of a gas bacillus infection. The patient was discharged June 21, with stump healed, having been in the hospital 112 days.

F. C. No. 56,575. White male, aged 27 years. The patient sustained a compound fracture of the right femur when his leg was caught in a bale of wire. On admission, February 20, 1916, there was a puncture wound over the site of fracture. The wound was cleaned and dressed and a cigarette drain placed in the wound. The leg was placed in Buck's extension. On February 26, the incision was lengthened for purposes of better drainage, pus having accumulated. On March 10, the wound was still draining pus, the bone ends were still denuded. On March 27, sequestra were removed. The wound had healed on May 1. On June 13, 1916, an open operation was done for correction of deformity, the fractured bone was plated, and the leg placed in a plaster cast. The plate was removed on July 14. The patient was discharged August 29, with bony union, but with 2 inches of shortening. The wound was granulating well. The wound had healed in 70 days; the patient was discharged on the 190th day.

T. E. No. 71,814. White male, aged 40 years. The patient was admitted on June 11, 1919. He had sustained a compound fracture of the left femur in a railroad accident. On admission the wound was cleaned, a drainage tube was placed in the wound, the wound was dressed and the leg was placed on a posterior Cabot splint. Death occurred later the same day.

8 Cases Treated Primarily by the Carrel-Dakin Technique.

L. R. No. 2,682. White male, aged 26 years. This patient was admitted on August 19, 1921, having been injured in an automobile collision. On examination he was found to have sustained a compound, comminuted fracture of the right tibia and fibula. There was a long lacerated wound over the site of fracture. The wound was débrided, and the leg placed on a Thomas splint with extension. The following day the sutures were removed and a reduction of the fracture attempted, following which the leg was placed on a posterior Cabot splint and Carrel-Dakin treatment instituted. On November 17, the wound was healed. November 30 an open reduction of the fracture was done and the fracture plated. He was discharged on December 20, with the leg in a cast. The wound was not quite healed; the bone, which was in good alignment, was covered by granulation tissue. Callus formation was poor. The man had a four-plus Wassermann. He was readmitted on February 17, 1922, and the Lane plate removed. He was discharged on February 22, with the wound not healed entirely but with bone union present. Under Carrel-Dakin treatment the wound healed in 90 days. His total time under hospital treatment was 188 days.

W. McH. No. 2,920. White male, aged 34 years. The patient was struck by an automobile on September 29, 1921. On examination there was found a lacerated wound over the lower left tibia, a compound fracture of the tibia underlying this, and a fracture of the fibula. On admission the wound was débrided and prepared for Carrel-Dakin treatment, and the leg was placed in a posterior Cabot splint. On October 3rd, and again on October 10th, the leg was manipulated in an attempt to reduce the fracture. On December 31st, the wound having previously been freed of organisms, the fracture was realigned by operation, and closure made by means of skin flaps. The wound was healed from this operation on February 19, 1922. On April 1st, there was firm bony union, and the patient was discharged with shortening of 1 inch. The wound had healed on the 143rd day, and discharge from the hospital was on the 184th day.

J. D. S. No. 675. White male, aged 34 years. The patient was run over by a truck and was admitted to the hospital on February 25, 1921. When examined he was found to have a compound fracture of the right femur, with a lacerated wound overlying the site of fracture. The wound was immediately débrided and left open for Carrel-Dakin treatment. Cultures from the wound showed a gram negative spore-bearing aerobic bacillus. On the 13th day following injury a secondary suture was performed but because of a chill and high temperature on the following day three sutures were removed. Cultures taken from the wound showed streptococci. The wound was then laid widely open. Carrel-Dakin treatment being continued. One week later an abscess which had formed in the groin was opened, streptococci being cultured from the pus. The wound over the fracture healed by granulation and was epithelialized on the 120th day. The patient was discharged on

the 123rd day, the fracture having united. On discharge he had 1½ inches shortening.

P. A. No. 67,612. White male, aged 21 years. Patient sustained a compound, comminuted fracture of the right tibia on August 16, 1918, while riding a motorcycle which was struck by an automobile. When examined on the day of the accident the tibia was exposed through the lacerated wound. The leg was cleaned and prepared for Carrel-Dakin treatment, and was placed on a posterior Cabot splint. On August 24, a sequestrum was removed, the fracture was wired and the wound partially sutured, drainage being established in the lower end of the incision; Carrel-Dakin treatment was continued as before the operation. The patient was discharged on October 3, the bone having united but the wound not having epithelialized. There was no shortening. The wound was not healed in 48 days; the duration of the stay of the patient in the hospital was 48 days.

G. P. No. 2,670. White boy, aged 7 years. The patient was run over by a truck and when examined on admission August 17, 1921, there was found a lacerated wound over the middle of the tibia, the fracture being just underneath the wound. The wound was débrided at once and Carrel-Dakin treatment instituted. The wound healed and epithelialized, but later a sinus developed and two small sequestra were removed on the 72nd day. More sequestra were removed at operation on December 15, and Carrel-Dakin treatment was again instituted. The wound was healed on the 169th day following admission, and there was firm bony union. The patient was in the hospital 190 days. When seen 3 months later there was no evidence of infection.

M. W. No. 66,247. White man, aged 38 years. The patient fell from a railroad trestle April 30, 1918. When examined at the hospital he was found to have a compound fracture of the radius and ulna. There was a lacerated wound over the fracture in which dirt and cinders were imbedded. The wound was débrided, including a rongeuring of the bone ends, and the wound was left open for Carrel-Dakin treatment. The ulnar artery had been severed by the accident and there was bleeding from the radial artery. An attempt was made to control this bleeding by pressure, but this was unsuccessful. Gas bacillus was reported as cultured from a swab taken from the wound the day of the injury. Because of the inability to control the hemorrhage an amputation was done through the middle of the forearm on May 15. The stump healed by granulation in 83 days, and the patient was discharged from the hospital on July 22, 1918, the 83rd day after admission.

A. H. No. 63,497. White male, aged 40 years. On September 9, 1917, the patient was thrown from a wagon. Examination showed that he had received a compound fracture of the left tibia and fibula with a lacerated wound overlying the fracture. The patient was received in shock, having also fractures of the clavicle, humerus and ribs. The

wound was cleaned and dressed, and the leg placed on a posterior Cabot splint. Carrel-Dakin treatment was instituted on the ward. The patient died the day following admission, not having rallied from the effects of his injuries.

A. G. No. 2,892. Black female, aged 22 years. The patient was admitted on September 16, 1921. She received a compound fracture when she fell from a third storey window. The wound was gaping with bone protruding. The wound was débrided, the fracture reduced, and the wound prepared for Carrel-Dakin treatment. Staphylococcus was cultured from the wound. Or November 23, a sequestrum was removed, and Carrel-Dakin treatment continued. The wound had not healed when the patient was discharged on the 85th day, though the bone was covered with granulations. There was bony union and the legs were of equal length.

26 Cases Treated Primarily by Débridement and Suture.

T. C. No. 10,130. White man, aged 43 years. The patient received a compound fracture of the right ulna when a piece of machinery fell on this arm. There was an extensive lacerated wound over the fracture. A débridement was done on August 16, 1922, the date of the injury. The skin edge and devitalized muscle were excised, the fracture reduced and the wound closed. Cultures showed only staphylococcus aureus. Stitches were removed on August 26, and the patient was discharged with the wound healed on August 29. The wound healed in 10 days and the patient was discharged on the 13th day.

C. L. No. 3,567. White male, aged 35 years. The patient was admitted on November 10, 1921, having just been shot through the right forearm. There was a compound comminuted fracture of the right ulna with a bullet lying against the ulna. There was a small skin wound. Culture from the wound showed only staphylococcus. The wound of entrance was excised, the bullet and some loose bone fragments removed, the tract curetted with gauze, the wound was washed with ether, and sutured with a rubber tissue drain; the arm was put up in a cast. On November 30, the wound was healed; the patient was discharged on December 2, the fractured bones being in good alignment. The wound had healed on the 20th day, and the patient left the hospital on the 22nd day.

D. P. No. 76,201. White male, aged 60 years. He received a gunshot wound resulting in a compound fracture of the right humerus on June 15, 1920. The wound was cleaned the same day, the skin edge excised, and the wound sutured. The wound healed in 10 days, the patient was discharged in 30 days with bony union present.

R. S. No. 10,861. White boy, aged 8 years. He was struck by an automobile on November 17, 1922, receiving a compound fracture of

the left tibia. The wound was débrided the same day, the skin edge and devitalized muscle excised and the fracture reduced. Cultures were negative. The wound was healed on December 6, and he was discharged in a cast on December 9. The bony union was firm and there was no shortening. The wound was healed on the 19th day, the patient being discharged on the 22nd day following the accident.

J. O'N. No. 5,378. White man, aged 55 years. He was struck by an automobile, receiving a compound fracture of the right fibula on May 22, 1922, the date of admission. The wound was débrided the same day, the skin edge and devitalized muscle being excised and the fracture reduced. The sutures were removed 9 days later and the wound was healed on June 6. The patient was discharged on July 3, 1922, with bony union. The wound had healed in 15 days; the patient was discharged from the hospital in 42 days.

J. C. No. 4,550. White male, aged 29 years. He was admitted to the N. H. H. on February 27, 1922, having sustained a compound fracture of the right tibia while riding in an automobile which overturned. He was operated upon the day of the accident. The wound was débrided, the skin edge and muscle excised, the bone rongeured, the fracture reduced, and the wound closed with a small rubber tissue drain inserted. Cultures from the wound showed no growth. The wound was healed on March 15. He was discharged on April 4, with bony union and with the leg in a cast. The wound healed in 16 days; the patient was discharged on the 36th day.

W. J. No. 77,538. White man, aged 28 years. The patient was pinned under an electric freight car. He received a compound fracture of the left tibia, there being a lacerated wound over the fracture. On October 4, 1920, the date of admission, a débridement was performed, the skin edge and devitalized muscle being excised and the wound closed. He was discharged, healed with bony union on November 1, 1920. There was no shortening of the leg. His stay in the hospital was of 27 days' duration.

F. D. F. No. 73,071. White boy, aged 8 years. On September 29, 1919, he was run over by an automobile, receiving a compound fracture of the tibia. There was a laceration over the tibia. He was operated upon the following day, a débridement being done with suture of the skin. On the date of admission the wound had been cleansed and swabbed with iodine in the accident room and the leg placed in a posterior Cabot splint. He was discharged from hospital on December 4, 1919. The wound healed in 2 weeks, and the patient was discharged in 66 days.

A. C. No. 72,202. White male, aged 18 years. The patient was admitted on July 19, 1919, right leg having been crushed in a motorcycle accident. There was a compound fracture of the right tibia and a

simple fracture of the right fibula. On admission, a primary débridement was done and the wound closed with rubber tissue drain. The cultures from the wound showed staphylococcus aureus. The wound was healed August 27, with 1 cm. shortening. The leg was placed in a cast and the patient discharged on August 30, 1919, using crutches. The healing required 39 days, and the patient was in the hospital 42 days.

M. P. No. 1,495. White male, aged 40 years. The patient was admitted May 4, 1921, a pile of lumber having fallen on his right leg. On examination he had a compound fracture of the right tibia and fibula with a large lacerated wound overlying it. The wound was débrided on admission. It had healed on May 24, the 20th day, and the patient was discharged on May 27, wearing a cast, the fractured bone being in good alignment.

J. F. No. 5,242. White male, aged 27 years. While starting a gas engine, the patient caught his leg in the spoke of the fly-wheel. He was admitted May 7, 1922. Examination showed that he had received a compound fracture of the left tibia and fibula, the bone having pierced the skin. The wound was débrided, the fracture was reduced, and the wound closed. A Finochietto heel stirrup was placed over the os calcis for traction. On June 9, the fracture having united, the leg was placed in a cast. The patient was discharged on June 17, with no shortening of the leg. The wound had healed in 33 days. The patient was in the hospital 41 days.

A. R. No. 76,004. White male, aged 33 years. On June 1, 1920, he was in an automobile accident in which his machine struck a telephone pole. He received a compound fracture of the left tibia, a puncture wound overlying the fracture. On admission the wound was closed by a primary suture. Cultures from the wound showed staphylococcus aureus. He was discharged on June 3, 1920, 2 days after, in care of his family physician, the wound being in good condition.

W. T. No. 74,740. White male, aged 52 years. The patient received a gunshot wound of the right arm, resulting in a compound fracture of the right humerus. He was admitted to the hospital on February 15, 1920, immediately following the accident, and débridement done at once. The skin edge and devitalized muscle were excised, the bullet was removed, the wound closed with a rubber tissue drain inserted. Cultures from the wound showed staphylococcus. He was discharged on February 19, 1920, the fourth day, the wound in apparently good condition, and the fractured bone in alignment.

F. L. No. 10,762. White man, aged 19 years. He was struck by a piece of wood on November 12, 1922, receiving a compound fracture of the right radius. The wound was débrided on admission. The skin edge and devitalized muscle were excised but the fracture could not be

reduced. The wound was closed. The sutures were removed on November 17, and healing was complete on November 23. On November 25, the fracture was reduced by open operation. On December 4, he was discharged with the wound healed and with the fractured bone in good position. The wound had healed in 11 days, the fracture was reduced after primary healing by open operation. The patient remained in the hospital 22 days.

G. R. No. 10,246. White boy, aged 18 years. While riding a motorcycle he ran into an automobile and sustained a compound fracture of the left tibia. He was admitted on September 1, 1922, the date of the accident, and the wound was immediately débrided, the skin edge and devitalized muscle being excised. The wound was closed, a small rubber tissue drain being inserted. Culture at operation was negative but from the rubber tissue drain which was removed in 24 hours staphylococcus was cultured. The stitches were removed on September 5 because of temperature and local pain and swelling. The bone protruded. The wound was then dressed with di-chloramine-T and was healed by October 10. The fracture was plated on October 13, and the plate removed on November 18. The wound was healed on November 27. He was discharged in an ambulatory Thomas splint on December 4, with firm bony union and with no shortening. The wound healed in 39 days, the bone being then plated. The duration of his stay in the hospital was 94 days.

M. M. No. 1,396. White woman, aged 37 years. When her automobile overturned she received a compound fracture of the right ulna. She was admitted to the hospital on the date of the accident, April 26, 1921, at which time a small puncture wound was found over the site of fracture. The wound was cleaned, a débridement was done, the wound closed with a Penrose sheath for 24 hours. Cultures taken at operation showed staphylococcus and streptococcus. Free drainage was established 2 days later, the wound being reopened. She was discharged May 7, against advice, the wound not being healed. The duration of her stay in hospital was 11 days.

H. R. No. 10,863. White male, aged 29 years. The patient was admitted on November 18, 1922. He had been hit by a freight train. Examination showed a compound fracture of the right humerus with considerable laceration and a puncture wound fracture of the right radius and ulna. The patient was received in shock, the arm cold and much swollen. A primary débridement of wounds of upper and lower arm was done. The wounds of the radius and ulna were débrided and sutured. They healed December 17 with bony union, the fractured bones being in fair position. The skin edge of the wounds of the upper arm was excised, subcutaneous tissue and muscle cut away, and closed with Penrose drain. On November 22, the wound was opened on account of pus. There was no crepitus. On November 27, the wound

was Dakinized; non-hemolytic streptococcus was found in the blood. On November 28, the wound was more widely incised and drained, and Dakin's tubes were inserted. On December 1, a necrotic biceps muscle was removed, together with two bone fragments; the wound was packed with gauze. On December 10, streptococcus was still cultured in the wound although the Carrel-Dakin was still being employed. On December 19, partial secondary suture was done, the bone ends were sutured with wire; Dakin's treatment was continued. On January 9, 1923, the fracture was rewired. On February 1, the patient was discharged; the fracture was not united, but bones wired were in good position and covered with granulations, the wound not having healed. The wounds of the forearm were healed in 29 days, but those of the upper arm were not healed on discharge, the 75th day.

B. G. No. 77,462. White man, aged 23 years. He was admitted to the hospital on September 27, 1920, having received a gunshot wound of the lower leg, resulting in a compound fracture of the left tibia and fibula. On the date of the accident the wound was débrided, the skin edge and the devitalized muscle excised, the bullet removed, the fracture reduced, and the wound closed. Cultures taken from the wound showed staphylococcus aureus, B. Proteus and a gas-producing bacillus which was not definitely proved to be B. Welchii. The wound was opened and drainage established on October 2. The wound granulated in until on December 12 there remained only a sinus. This sinus led down to bone, and on December 15 he was operated on and a small sequestrum was removed. The wound healed and he was discharged on December 22, bony union firm, there being no shortening of the leg. The wound healed in 86 days, at the end of which period the patient was discharged.

J. T. No. 3,279. White male, aged 37 years. On the date of admission, October 12, 1921, the patient was in an automobile accident in which he was thrown against the side of a truck. He received a compound fracture of the right tibia. On examination a puncture wound was found over the fracture. He was operated upon and a débridement was done. The skin edge and devitalized muscle were excised and the bone ends were rongeured. There were no foreign bodies, the fracture was reduced and the wound closed with a small rubber tissue drain. Cultures were negative. The recovery was uneventful until November 10, when a pus pocket opened and the ends of the fractured tibia were exposed. Roentgenograms repeated during the next 2 months showed no sequestra, but on January 10, 1922, a sequestrectomy was performed. On January 14 the stitches were removed because of inflammation and discharge, and Carrel-Dakin treatment was instituted. By February 4, the wound was healed. The patient was discharged on March 25, healed with firm bony union and walking with crutches. The wound healed on the 115th day; the patient was discharged from the hospital on the 164th day.

C. P. No. 74,942. White man, aged 41 years. The patient was admitted on December 15, 1919, having been struck by an automobile while riding a bicycle. He received a compound fracture at the junction of the middle and lower third of the left tibia. The wound, which was lacerated, was cleaned and sutured on admission. Cultures taken were negative. On the following day two sutures were removed and a gauze pack was inserted to control hemorrhage. The wound had healed out by January 20. He was discharged with a cast and on crutches January 26, but was readmitted on March 3, 1920, complaining of nonunion. Examination showed an ulcer with bone protruding at the site of fracture. Cultures taken showed staphylococcus. The wound was Dakinized, and on March 8 the ulcer was excised and sequestered bone removed. The wound was closed and healed by primary union on March 17. He was discharged on April 6, 1920, with well marked callus formation, wearing a cast and on crutches. The wound had healed on the 72nd day, and the patient was in the hospital 112 days.

C. L. No. 76,333. White boy, aged 6 years. While sliding for first base in a baseball game his leg was stepped on and he received a compound fracture of the left tibia. He was admitted to the hospital on June 24, 1920, the day following the accident, having been treated at home. On admission the wound was débrided, the skin edge and the devitalized muscle excised, the fracture reduced, and the wound closed. Cultures from the wound showed staphylococcus. The wound was opened 2 days later and was drained, Dakinization later being instituted. The infection had cleared and the wound was entirely healed on July 26. He was discharged with the leg in a cast on July 31, 1920. The wound healed in 32 days, and the patient was discharged from the hospital in 37 days.

F. L. No. 78,678. White male, aged 52 years. The patient was admitted on December 29, 1920, having cut his left forearm on a buzz saw. There was a large lacerated wound overlying a compound fracture of the left ulna. The wound was débrided and closed, the ulna having been united with kangaroo tendon; the wound was closed without drainage, the arm being placed in a cast. Cultures taken from the wound showed streptococcus, staphylococcus, and gas bacillus. On December 31 there was crepitus over the forearm. The arm was amputated above the elbow, and the stump treated by the Carrel-Dakin method. On January 3, 1921, streptococcus and gas bacillus were cultured from the stump. The patient was discharged on February 12, 1921, stump not yet healed. The duration of the stay in the hospital was 45 days.

A. F. No. 1,508. White male, aged 38 years. He received a gunshot wound of the left thigh resulting in a compound fracture of the left femur on May 5, 1921. The wound was incompletely débrided the following day on the patient's admission to the hospital, and closed. Roentgenogram taken following the operation showed lead particles in the

wound. Bacteriology report 20 hours after operation from wound cultures showed no anerobes. Cultures from the knee on the third day post-operative showed streptococci, and from the wound B. Subtilis. Cultures from the wound on the fourth day were negative for anerobes. The pulse and temperature had been gradually rising during these four days even though the wound was opened. On May 9, it was noted that there was considerable drainage from the wound, that the skin was bronzed, and that no crepitation could be made out. On May 10, the leg was amputated through the infected field. The patient died on May 12. Blood cultures had been negative; the W. B. C. was not over 12600, and the polymorphs not over 77% at any time. The laboratory findings were of little value until May 9, when streptococcus was reported. The post-mortem diagnosis was gas bacillus infection and streptococcus septicemia. Death occurred on the 7th day.

J. J. R. No. 76,003. White male, aged 33 years. The patient was admitted to the N. H. H. on June 1, 1920, following an automobile accident in which the patient was thrown through the windshield of his automobile when it hit a telegraph pole. On admission a compound fracture of the left femur was found, with a lacerated wound overlying. This wound was débrided and closed. He died on the following day from thrombosis.

J. K. No. 10,871. White boy, aged 10 years. This patient was injured in an automobile accident on November 18, 1922. He received a compound fracture of the radius and ulna. The wound was débrided and sutured. Cultures taken from the wound were negative. The wound healed in 22 days, at which time the patient was discharged. The bones were united and in good alignment. He was discharged with the arm in a sling.

5 Cases Treated Primarily by Amputation.

A. P. No. 56,342. White male, aged 33 years. The patient was caught in a rock crusher and received a compound fracture of the right tibia and fibula on January 27, 1916, the date of admission. The posterior tibial artery being severed, it was thought necessary to amputate. This was done at the level of the upper and middle third of the tibia. The end of the stump healed by granulation, May 8, and the patient was discharged on June 7. The stump had healed in 101 days; the patient remained in the hospital for 131 days.

F. C. No. 57,905. White boy, aged 14 years. The patient was hit by a train on June 11, 1916, receiving a compound fracture of the right radius and ulna. On admission the same day, the wound was cleaned and dressed with a moist 1-10000 bichlorid dressing. Because of the severing of the vessels it became necessary to amputate the arm, and this was done on the same day. He was discharged with the stump healed on July 19, 1916, the 38th day.

F. S. No. 59,614. White male, aged 25 years. The patient was admitted to hospital on November 3, 1916, having been hit by a locomotive. He received a compound fracture of the left tibia and fibula, the lower leg being severely macerated. On admission an amputation was done through the lower end of the femur. The patient was discharged December 24, the stump being healed over. His stay in the hospital covered a period of 51 days.

C. C. No. 69,656. White male, aged 52 years. The patient was hit by a trolley car on December 3, 1918, and received a compound fracture of left tibia and fibula. On admission the leg was hanging by a shred. the foot was cold, and an amputation through the lower end of the femur was performed the same day. He was discharged April 10, 1919, with stump healed; his stay in the hospital having been 128 days.

H. P. No. 55,175. White male, aged 19 years. He was injured in a collision while riding a motorcycle, and received a compound fracture of the tibia, with laceration. On admission, October 12, 1915, he was taken to the operating room and the leg was amputated at the lower end of the femur. The stump became infected and a re-amputation of the stump was necessary on December 17, the edges of the skin flaps being approximated. He was discharged with the stump healed on January 24, 1916. The patient was in the hospital 104 days.

CONSTRUCTIVE THERAPY OF BONE AND JOINT TUBERCULOSIS.*

BY R. PLATO SCHWARTZ, M. D.

J. N. Adam Memorial Hospital, Perrysburg, N. Y.

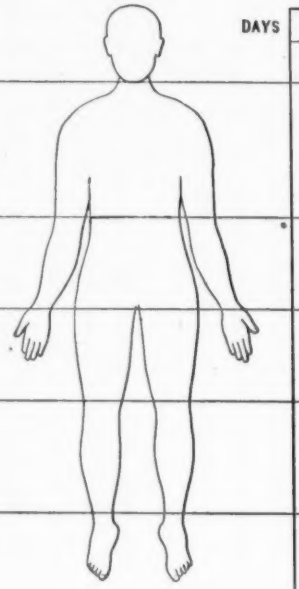
To prevent the total loss of function and the recurrence of disease in a tuberculous bone or joint the patient should be treated systematically; excessive atrophy of specialized structures should be prevented; and surgical measures should be regarded as rarely if ever indicated. The accepted method of treatment has directed attention only to the part affected, leaving the primary lesion unrecognized or untreated; it has enforced immobilization over a period of months without regard for the degeneration known to result from non-use; and too frequently it has instituted such radical surgical procedures that restoration of even a small degree of function was hopeless.

Ankylosis has been accepted as the most desirable end-result of a tuberculous joint on the ground the any degree of function favored a recurrence of the disease. It seems that, on the whole, therapeutic measures have been confined to the treatment of a part which represented only one phase of a generalized tuberculous process. Therefore the recurrence of disease in a healed tuberculous joint might be due more to the presence of the virulent organism which remains elsewhere in the body, than to the small amount of motion which is present in the treated joint.

Lo Grasso[1] has reported the presence of pulmonary lesions in 78% of 634 adult osteo-articular cases, and he also states that in a large number of patients with Pott's disease, especially those in which the lower dorsal and lumbar region is affected, tubercle bacilli are found in the urine. Osler[2] states that the renal infection may result from a direct extension of the disease from a tuberculous vertebra. Rollier[3] reports the presence of a pulmonary lesion in 30% of his osteo-articular cases. Until recently these facts have not been recognized and at the present time their importance is not fully appreciated, as is shown by the fact that, in general, thera-

*Read before the Buffalo Academy of Medicine, May 9, 1923.

DR. ROLLIERS SCHEMATIC DIAGRAM OF INSOLATION



DAYS	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	
					5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	From the 10th to the 15th day, increase according to the same scale.
				5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	From the 15th day, all the previously exposed portions of the body should receive the same amount of insolation as the longest exposed part,—increasing the time 5 minutes daily, till a bath of from 3 to 4 hours is taken.
			5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	
		5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	
	5 Min.	10 Min.	15 Min.	20 Min.	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	50 Min.	

THE PROGRESSION BY WHICH THE PATIENT IS EXPOSED TO THE SUN

peutic efforts are confined to the local lesion and but little consideration is given to overcoming the systematic infection.

The presence of a tuberculous lesion in any patient is sufficient evidence that the individual was unable to meet the resistance offered by his particular environment. It is generally admitted that bone or joint tuberculosis is usually a secondary lesion; therefore any patient thus afflicted should be regarded as systematically tuberculous. Under these conditions treatment must be simultaneously directed toward both the primary and secondary lesions; simply because the bone disease is more prominent is not sufficient reason for withholding effective therapeutic measures from the man in favor of the limb. If the general resistance of the patient is not materially increased during the time required for a tuberculous bone or joint to heal it is not well to advise him to return to his old environment in which he broke down.

The application of heliotherapy in the treatment of this affection makes it possible to mobilize the patient's total reserve for meeting the infection wherever it may be. The Rollier technique as introduced by Pryor and practiced by Lo Grasso at the J. N. Adam Memorial Hospital is the most effective method yet devised for the administration of general air and light baths. The body is divided into five zones, as in the accompanying illustration; the head, which should always remain shaded, is not included. On the first day a white sheet covers the patient to a point just above the ankles; the feet, front and back, are exposed to the sun's rays for a period of five minutes, with one hour interval between each of three exposures. The total time of exposure for the first zone on the first day is, therefore, fifteen minutes divided into three five-minute periods, separated by intervals of one hour. On the second day the same procedure is repeated and at the end of each five-minute period the legs are exposed to the knees for an additional five minutes. The first zone, therefore, receives on the second day a total of thirty minutes, while the second zone receives a total of fifteen minutes exposure. On the sixth day, for example, the first zone receives ninety minutes, the second zone seventy-five minutes, the third zone sixty minutes, the fourth zone forty-five minutes, and the fifth zone thirty minutes.

There is no rigid formula by which all patients may be treated. On the contrary each patient is a law unto himself, and it is never wise to proceed more rapidly than the above method indicates if the serious effects of

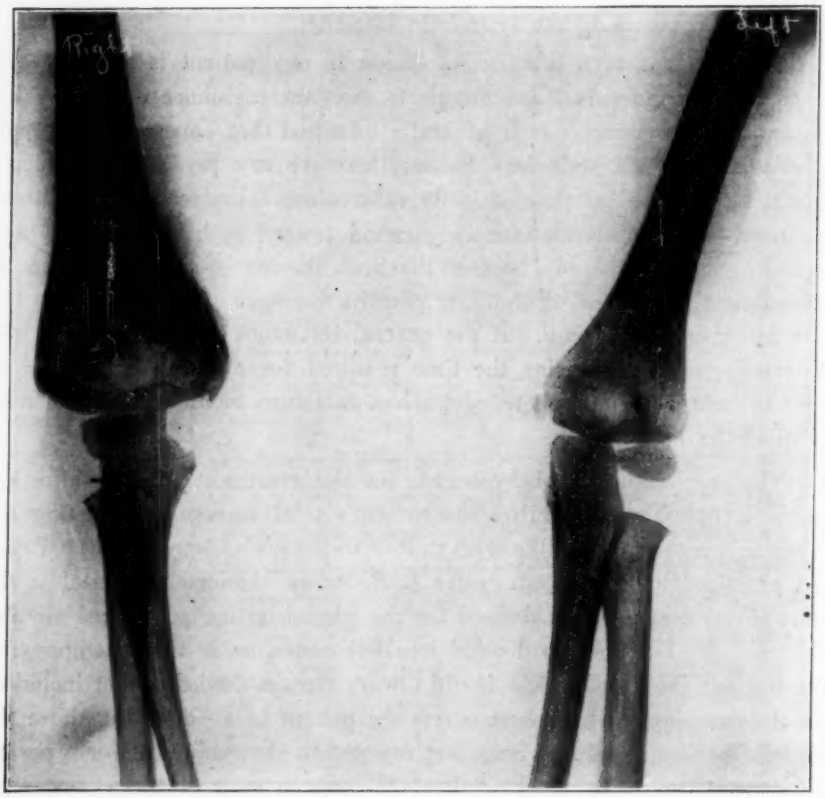


Fig. 1. X-Ray of both elbows, July 11, 1922. Two discharging sinuses were draining freely on the right. Flexion was possible to 45° degrees, extension was limited to 150°, pronation complete, supination to 90°.

insolation are to be avoided. It is obvious that the patient with multiple lesions or serious pulmonary complication must be started with far greater caution than one who is more robust and less affected by the generalized infectious process. In such cases it may, therefore, be advisable to make the initial exposures much shorter than the foregoing schedule has outlined, and in no case should the successive exposures total more than three to four hours in twenty-four.

All forms of therapy are usually effective within certain limits. Frequently combinations are more desirable than the rigid application of one

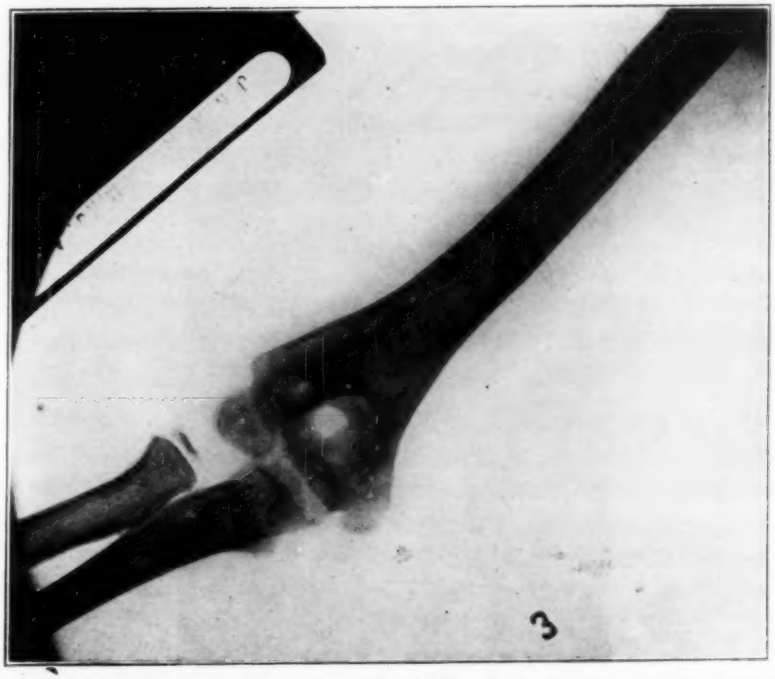


Fig. 2. X-ray of rt. elbow, June 27, 1923. Both sinuses healed since Nov. 1922.

Range of Motion		
Rt.		Lt.
170	Ext.	180
130	Flex.	140
180	Sup.	180
180	Pro.	180

creed, and the good results of any procedure are more dependent upon the recognition of the fundamental indications than upon the exact procedure by which those indications are met. The practice of long, continued immobilization is not an exception to this rule, as was shown by Legg[4] in 1908. His experiments led to the conclusion that the amount of atrophy seen in joint disease is wholly proportional to functional inactivity. Allison and Brooks[5] have shown that bone atrophy results from simple confinement of the patient in bed, which is of considerable clinical interest, particularly since it concerns children. These facts are valuable contributions, but tuberculous joints are still being religiously immobilized in ac-

Fig. 3 Photograph taken Oct. 29, 1923. Flexion 5° less than in normal left elbow. Note scar on medial condyle.

cord with the teachings of Hilton, Hunter, and Thomas. The atrophy of non-use contributes to the production of deformity and the impairment of function even in the absence of disease due to the degeneration of specialized structures. It should be emphasized that long, continued immobilization of a tuberculous joint over a period of months or even years may be second only to extensive destruction in producing deformity and partial loss of usefulness. Intra-and periarticular structures may undergo a sufficient degree of degeneration due to atrophy alone, so that it would be difficult if not impossible to fully restore their function.

For the above reasons tuberculous joints should not be rigidly immobilized during the entire time required for healing. Immobolization is indicated in the presence of pain, swelling, and muscle spasm. However, as these symptoms subside, immobilization should be gradually discontinued and graduated active exercises should be instituted.

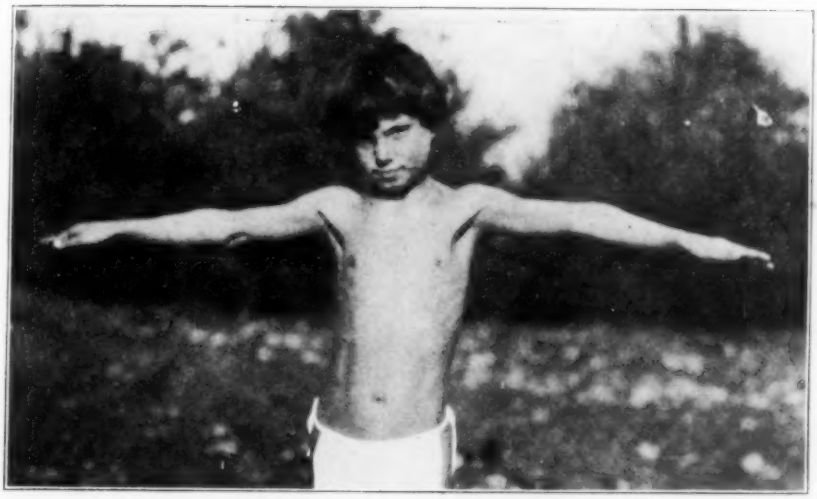


Fig. 4. Photograph taken Oct. 29, 1923. Extension equal to that in normal left elbow.

It seems that the presence of discharging sinuses is not always a contraindication to the treatment suggested. A girl, age seven years, had a tuberculous right elbow of eighteen months' duration on June 6, 1922. There were two discharging sinuses, medial and lateral surface respectively; the forearm could be extended to 150 degrees and flexed to 45 degrees, giving 15 degrees of active motion. At present she has full range of motion and both sinuses have been closed during the past nine months of relatively unrestricted activity. Heliotherapy, carefully supervised active and passive exercises, without any attempt to immobilize the joint since June, 1922, is the combination which proved to be effective in this case.

It would seem that the results obtained by surgery alone would of themselves make an urgent call upon the profession for a more efficient therapeutic procedure, for as a whole they have been exceedingly poor. FitzSimmons[6] states that "a large proportion of cases of tuberculosis of the ankle joint and tarsus are more likely to get good functional results in a shorter time by the non-operative procedure." Rogers and Peabody[7] feel that irrespective of the amount of motion in a case of healed hip disease, an operation is indicated to produce ankylosis in a favorable position. Osgood, Soutter[8] and their colleagues, in criticizing this point in surgical

Fig. 5. Photograph taken Oct. 29, 1923, showing scar on lateral surface of right elbow.

judgment, state that they are unwilling to give up striving to devise methods of cure of tuberculosis of the hip with useful motion remaining, for if this fails it is always possible to resort to arthrodesis. Operative procedures are essentially destructive, in that, by attempting to remove the focus of disease, the granulation tissue, which serves as a protecting wall to the surrounding normal structures, is likewise broken down, opening new areas to infection and increasing the possibility of aggravating the generalized tuberculous process, which occasionally ends in meningitis.

CONCLUSIONS.

Tuberculosis of bones and joints, like all other local manifestations of this disease, should be regarded as the result of a generalized infectious process.

Treatment of the local manifestations becomes most effective when it mobilizes the patient's resistance against the systemic infection which preceded the local lesion. Such a therapeutic agent is available in the form of heliotherapy.

Immobilization is indicated for the correction of deformity and the relief of pain and muscle spasm. Definite departure from routine immobilization methods is indicated to prevent degeneration known to result from non-use.

Surgical measures may be indicated to improve function subsequent to healing of the tuberculous lesion.

The restoration of function is a more desirable end-result than ankylosis.

The privilege of making these observations was fostered by the combined efforts of two men. The keen vision and indomitable spirit of the late Dr. John H. Pryor resulted in the erection of the J. N. Adam Memorial Hospital for the application of heliotherapy to all forms of tuberculosis. Through the administrative and professional efforts of Dr. Horace Lo Grasso, the Superintendent, a sufficient number of cases have been treated under his direction since 1913 to firmly establish the indications for heliotherapy in tuberculosis. The writer therefore wishes to acknowledge his indebtedness for the advantages which have been so willingly extended to him.

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THE ETIOLOGY AND TREATMENT OF CLAW FOOT.*

BY G. PERCIVAL MILLS, BIRMINGHAM, ENGLAND.

My attention was drawn to the deformity of claw foot because I could find no adequate explanation for it. The charm of the unknown is particularly gratifying in these days when surgery is rapidly becoming reduced to a mechanical system instead of being, as in the past, the most interesting of the arts. We have discovered fairly satisfactory explanations for most of the acquired deformities of the body and made highly ingenious guesses as to the origin of congenital ones but so far none of the various suggestions as to the cause of claw foot has received general acceptance. How varied these suggestions are is well seen on consulting a standard text book on orthopaedic surgery in which I found eight separate causes given for this singularly precise and definite deformity. The impression left on my mind from reading the list was one of surprise that anyone managed to escape the disease. I was also reminded forcibly of the remark of one of my surgical teachers to the effect that, when a number of different forms of treatment were given for one disease, no one of them was satisfactory.

Now, even at the risk of prolixity, I should like briefly to outline the characteristic deformity present in this disease. The front of the foot is dropped in the line of the heads of the metatarsal bones and this dropping appears to occur at the mid-tarsal joint and is not dependent on any shortening of the tendo Archillis. The great toe is hyperextended at the metatarso-phalangeal joint and fully extended at the interphalangeal joint. The four outer toes are hyperextended at the metatarso-phalangeal joints, flexed at the proximal interphalangeal joints and normally extended at the distal interphalangeal joints, while they are usually slightly adducted towards the middle line of the body. In advanced cases there is also a tendency for the whole foot to become varoid. The great toe is usually in good position as regards lateral deviation, and I would ask you to note especially the absence of hallux valgus. As with other deformities, the condition is passively correctable in early cases but no longer so in advanced cases. It becomes fixed by adaptive shortening of the extensor proprius hallucis, the long flexors of the toes, and the plantar fascia.

*Read before the British Orthopaedic Association, October, 1923.

The condition of the tendo Achillis is of special interest, for a shortening of this tendon has been considered by some writers to be an integral part of the deformity. A dropping of the front of the foot, of course, causes an apparent shortening of the tendo Achillis in the sense that it becomes difficult to get the heel to the ground but, if the position of the heel only be considered, such shortening is found to be the exception rather than the rule. Of 64 cases examined from this point of view, the tendo Achillis was found to be shortened in only 17 and of normal length in 47. Moreover, it was in the older and more advanced cases that it was shortened. Of the 17 cases with shortening, the average age was 22½ years, whereas in the whole series the average age was under 14 years. Shortening of the tendo Achillis, therefore, is not an essential factor in the deformity of claw foot but may be regarded as a complication, depending probably on associated paresis of the opposing muscles.

A further point in the nature of the disease which claims attention is how far it is correct to regard it as a progressive condition. The tendency of the literature to which I have had access is to regard this deformity as a definitely progressive one, which must always be treated radically to avoid very serious disability. While not denying the progressive nature of certain cases, I think this character has been much exaggerated. I know of one case which existed for twelve years without treatment and was still only in the so-called second stage, and my experience of the treatment of early cases by such simple means as a night splint and metatarsal bar is that most of them recover without operation. This was contrary to what I expected from my reading and therefore struck me forcibly.

Claw foot, as thus defined, is a fairly common condition, in the Midlands at any rate. My colleague, Mr. J. B. Leather, has kindly allowed me to use his cases with my own for statistical purposes as to age and sex, and I find we have seen 99 cases during the last five years. Of these, 54 were males, with an average age of 13¼ years, and 45 were females, with an average age of 14½ years. The condition was unilateral in 42 and bilateral in 51; not stated in 6. Of the 52 cases in my own series, varus was also present in 4. It is clear, therefore, that the disease occurs in adolescents, rather more commonly in boys than in girls, and is fairly frequent in the hospital class of patient. It is a curious fact, but I do not remember having seen a case in private practice. This, of course, may be merely my misfortune but I should be interested to hear the experience of others on the point.

ETIOLOGY.

The uncertainty of the etiology is the great charm of this deformity. Among the various suggestions that have been made, the following are perhaps the most reasonable.

1. That it is due to a temporary paralysis of the anterior muscles of the leg allowing a dropping of the front of the foot, which dropping is maintained by a secondary contraction of the plantar fascia. This is an attractive hypothesis but the great difficulty is that exactly the same thing is invoked to explain the origin of right angled contraction and mild degrees of talipes equinus. Why such transient paralysis, which may quite reasonably produce these latter deformities, should in other cases produce the entirely different condition of claw foot, is still unexplained, and until such explanation is forthcoming, this hypothesis cannot be considered to cover the facts.

2. That it is due to a temporary paralysis of the tibialis anticus only. This modification is evidently designed to get over the above difficulty. If the long extensors remain active, the clawing of the toes might possibly be explained by the drag on these tendons from dropping of the foot. The difficulty here is that a claw foot always tends to be varoid rather than valgoid and that weakness of the tibialis anticus is a recognized cause of valgus and even of flat foot. To adduce the same weakness as a cause of varus and hollow foot is rather a strain on one's credulity. Moreover, I have noticed in cases of claw foot that the tibialis anticus is frequently very strong and active.

3. That it is a postural deformity due to bad boots, especially those with high heels and rocker soles. No one, of course, denies that such boots will produce deformity and the common age of onset of claw foot is about that time in life when the effect of boot-wearing might be expected to become noticeable. There are, however, grave difficulties in accepting this view. The first effect of bad footwear is almost invariably the production of hallux valgus and this deformity is rather conspicuously absent in early claw foot. Once again, too, we have the anomaly of explaining flat foot and hollow foot by the same imperfect boots. Moreover, the more extravagant varieties of footwear appear to be associated, in girls at any rate, with the onset of the secondary sexual characters at puberty and, since the average age at which the patients sought treatment was 14, very little time is allowed for the deformity to be produced. Secondly, the fact that nearly half the cases

occur in one foot only (42 out of 99) and about equally in right and left, is against a static origin. Finally, I think the sex ratio is conclusive evidence against this view. Girls notoriously wear more deforming boots than boys, and were boots the cause of claw foot one would expect a preponderating number of cases in girls and an earlier average age of onset. As a matter of fact, of 99 cases, 54 were in males and 45 in females: the average age at which the males sought treatment was 13¼ years, the females, 14½ years. The deformity is therefore commoner in boys and tends to come on at a rather earlier age than in girls.

While these facts prevent me from accepting bad boots as the primary cause of the deformity, I do not deny that they may have some connection with it. If it were shown, for example, that the original cause were some transient muscular paralysis or weakness, the wearing of boots would certainly modify the deformity thus produced so that the result would be different from that produced by weakness of corresponding muscles controlling the hand. It is just this factor of weight bearing in boots that makes it so much more difficult in the foot than in the hand to calculate the effect of any given paralysis.

4. That it is an ischaemic paralysis. An advanced claw foot certainly has somewhat the appearance of an ischaemic paralysis but there is little evidence in favor of this view. The deformity cannot be explained by the ischaemic contracture of any group of muscles, and in only one case in my series did I obtain any history suggesting such an origin. This was a case which was alleged to have followed the tight bandaging of a fractured ankle in infancy.

5. That it is a primary contraction of the plantar fascia following disease or injury. This may be an occasional cause but, as the usual cause, it fails for lack of evidence. Of my own 52 cases, one certainly followed cellulitis of the sole from an infected wound and one had a history suggesting plantar rheumatism. In the others there was no evidence to suggest such an origin.

6. That it is due to temporary paralysis or weakness of certain muscles in the sole and therefore comparable to the deformity produced by ulnar paralysis in the hand. This view was introduced by Duchenne and is extremely ingenious and attractive. Its failure to be generally accepted is due, I think, to his relying largely on the alleged inability of these muscles to be stimulated electrically, a fact which has not always been sup-

ported by later investigation. It is not necessary, however, to postulate complete paralysis with loss of electrical reactions: if a temporary paralysis or weakness occurs, a deformity may be produced which will be perpetuated by secondary contractures and possibly by boots. It is worth considering, therefore, whether the typical deformity could be produced by paralysis of any group of small muscles in the foot. If we can show that it corresponds very closely to what would be produced by such a paralysis, we have a very strong case: if we can show that the correspondence is correct to the minutest detail, we have something very nearly approaching proof.

The muscle group which, from the analogy of ulnar paralysis, first invites attention is that supplied by the external plantar nerve. These muscles are the interossei and outer three lumbricals, the accessorius, the abductor hallucis, and two small muscles acting on the little toe only, the abductor and flexor brevis minimi digiti. I am in the habit of teaching students that the way to discover the deformity that will result from any given paralysis is to ascertain the exact action of the paralysed muscles and to put the limb into the diametrically opposite position. The actions of the muscles are taken from Morris' Anatomy, but for the sake of simplicity we can neglect the two small muscles acting only on the little toe.

The combined action of the lumbricals and interossei is to flex the metatarso-phalangeal joints and extend the interphalangeal joints of the four outer toes. Paralysis should therefore cause hyperextension at the metatarso-phalangeal joints and flexion at the other two. The flexor accessorius, however, flexes the terminal phalanges of the same toes and its paralysis will balance the effect of paralysis of the interossei on these joints. Consequently the terminal phalanges should take a neutral position, possibly dictated by the pressure of the boot. The accessorius has also an important action in preventing the obliquely placed long flexor tendons from adducting the toes. Its paralysis should therefore result in a tendency to adduction of the four outer toes. The adductor hallucis adducts (from the median plane of the body) and flexes the proximal phalanx of the great toe. Its paralysis, therefore, should cause hyper-extension of the proximal phalanx, any marked degree of adduction being, of course, prevented by the wearing of boots. No lumbricals nor interossei go to the great toe, so the distal phalanx is unaffected and retains its normal position of extension. Finally, it might be expected that the continued oblique pull

of the flexor longus digitorum, unbalanced by the accessorius, would produce a tendency to varus of the whole foot.

If I have succeeded in making myself clear, it will be agreed that the deformity to be expected from this paralysis bears a very close resemblance indeed to that found in claw foot, a resemblance too close to be merely accidental, and going far to justify the view that external plantar paralysis is the cause of the condition.

For complete proof, of course, we need much more than this: we need a definite history of the paralytic attack, and this I must own is seldom forthcoming. It is obvious, however, that such a paralysis would not be noticed by an untrained observer and the patient does not seek treatment until the deformity begins to be obvious. The usual history is that the patient often after an infectious disease, began to walk badly for a time, then more or less recovered, and that later the deformity was noticed. Exactly the same story, in fact, as in cases of right angled contraction which are considered to be due to temporary weakness of the anterior leg muscles. If so obvious a paresis passes unrecognized, how much more readily would a paresis of the small foot muscles escape observation. In only nine cases out of fifty-two was I able to obtain evidence of antecedent paralysis. One very advanced case was suffering from progressive muscular atrophy due probably to weakness of the interossei and lumbricals which occurs early in this disease.

Experiments on the electrical reactions have proved equally uncertain but, *ex hypothesi*, it is not to be expected that actual paralysis will be found at the time of examination. For example, in one case which had a definite history of paralysis at the start, the electrical reactions were found to be normal when the deformity had developed. Stimulation of the muscles of the foot individually is hardly practicable, but in a number of cases I had the interossei tested by means of a Faradic bath and the abductor hallucis was tested individually. This latter muscle, which is, of course, supplied by the internal plantar nerve, was always active. The interossei, out of 29 cases, appeared normal in 23, while the response was weak in 5 and absent in one. That this is only a very rough test is evident from the fact that the case of progressive muscular atrophy, in which the deformity and wasting were extreme, was classed as reacting normally.

Though the evidence is admittedly imperfect, I am inclined to regard paralysis or paresis of the external plantar nerve group as the cause of most cases of claw foot. When there is shortening of the tendo Achillis also,

we may reasonably assume that there has been paresis of the tibialis anticus at the same time.

TREATMENT.

I do not propose to discuss this at length, as it is being dealt with in another paper, but will merely indicate my own methods and results.

Early cases are treated quite simply by a rectangular night splint and a metatarsal bar to the boot. Of 10 such cases, 9 did so well that no question of further treatment arose, while one was subsequently operated on. The success of such treatment in early cases is additional evidence in favor of temporary paralysis as a cause. I remember one case in particular in which, after six months treatment, I could hardly believe the patient had ever had a claw foot. Some of the others, however, ceased to attend, so I cannot be certain if the deformity was cured or the symptoms only relieved.

Moderate cases are treated by fasciotomy, wrenching and transplantation of the extensor proprius hallucis to the metatarsal bone, with division of the long flexor tendons and lengthening of the tendo Achillis when necessary. At first I doubted if the extensor proprius hallucis was strong enough to do the work required of it and suspected that the good results of the operation were due to the correction of deformity combined with division of the tendon. I was completely convinced by a fortunate accident. In March, 1922, I operated on a bilateral case: seven months later the right side was perfect but the left had relapsed. I then discovered that the tendon on this side had come loose. I reattached the tendon in January of this year and the foot is now well. The operation is a good test of technique in tendon transplantation for it is usually easy to see if the tendon is acting or not. It may act strongly by the end of a month but occasionally it may not act visibly for several months. Electrical stimulation of the muscle is a very valuable aid in getting it to start. Of 31 cases in which a note was made, it was acting in 25, doubtful in one and not acting visibly in four. In one case, as stated above, it became detached.

The clinical results of this operation are very good if the proper after treatment is carried out. I order massage and electrical stimulation of the transplanted muscle until the tendon acts well, and the patient wears a metatarsal bar for six months and a rectangular night splint for a year.

The results of the cases I have treated are as follows:

Total cases—45.

Done within six months and therefore too early to assess, but at present satisfactory—8.

Good result at least six months after operation—19.

Good result as regards claw foot but slight varus present—2.

Unsatisfactory result—4.

Untraced—12.

That is to say, of 25 cases traced over six months, the result is entirely satisfactory in 19 and nearly so in two others. Of the four unsatisfactory cases, two had entirely neglected after-treatment. The deformity had not recurred but the patients complained of some pain in the foot so they cannot be classed as cures. The only case of recurrence of deformity after operation is the one in which the tendon came loose.

Of advanced cases needing excision of bone, I have treated only four. In the first three I did the operation advised by Sir Robert Jones of excising half an inch of the inner four metatarsal bones. I do not know if I made any error in technique but in each case the head of the fifth metatarsal bone became very prominent in the sole and caused such pain in walking that I subsequently had to excise part of that bone also. Consequently in my fourth case I divided the fifth metatarsal at the original operation and have been quite satisfied with the result. In one of the cases I had also to do an astragalectomy for varus.

CONCLUSIONS.

1. Claw foot is an acquired deformity, occurring most frequently in adolescents and rather more commonly in males than in females.

2. Shortening of the tendo Achillis is not an essential part of the deformity but is present as a complication in about one quarter of the cases.

3. The deformity is such as would be theoretically expected from paralysis of the external plantar nerve.

4. The evidence that temporary paralysis or paresis of this nerve is the cause of the deformity, while not complete, is certainly suggestive.

5. In early cases simple treatment by splints and boots will often avoid the necessity for operation.

6. For moderate cases transplantation of the extensor proprius hallucis is a satisfactory operation.

7. In advanced cases, when portions of the inner four metatarsals are removed, it is advisable to divide the fifth metatarsal at the same time.

SEPARATION OF THE QUADRICEPS FROM THE PATELLA. REPORT OF TWO CASES.

BY ISADORE ZADEK, M. D., NEW YORK, N. Y.

Separation of the quadriceps tendon from the patella is rarely encountered. Rupture of the quadriceps tendon, while uncommon, is observed more frequently.

Violent contraction of the quadriceps extensor may result in fracture of the patella; the patellar tendon may pull a portion of the tibial tubercle off the tibia; the patellar tendon may be torn or the continuity of the quadriceps may be broken.

Fracture of the patella is not uncommon. If the fracture is due to indirect violence, the patella is fractured transversely, and if the lateral expansions of the aponeurosis of the quadriceps are likewise torn, there is separation of an inch or more of the fractured surfaces of the patella, associated with a marked hemarthrosis of the knee joint. The importance of the aponeurosis of the quadriceps is evidenced by the fact that after injury a transverse fracture of the patella may occur and yet the patient suffer relatively slight disability and no displacement when the lateral expansions of the quadriceps are not torn. Fracture of the patella in these cases is hardly suspected and is shown only by the X-ray. Fracture of the patella due to direct force usually results in comminution, with but little displacement of the fragments, because the lateral aponeurosis is not torn.

It has been suggested that underlying disease, for instance arteriosclerosis, may be a factor in rupture of the quadriceps tendon, as in the reported cases the condition has occurred usually in adults of about fifty or more years, and especially in men. There have been a number of instances reported in which both quadriceps tendons were torn. A survey of the literature shows that the cases of ruptured quadriceps treated by suture were uniformly better than those not operated upon.

The two cases which I wish to report do not belong to this group and it seems likely from their histories that there is an underlying developmental weakness.

Case No. 1. Photograph taken January 17, 1923, showing range of active flexion and extension of the injured knee seven months after operation.

CASE NO. 1. E. B., female, age 20, was first seen June 21, 1922, in Dr. P. W. Roberts' clinic at the Hospital for Ruptured and Crippled, when she gave the following history: Three months ago she fell down the steps and the left knee became swollen and very painful. For awhile she was unable to bend the knee. The swelling then decreased. Two months later she fell again and the same knee became swollen and painful. She had had no treatment. She felt that after the first two injuries to the knee, she did not quite completely recover and that the disability has been more marked with each successive injury until the present disability, which is practically complete. This morning patient fell while going down the steps. The left knee was flexed as patient fell, so that the toes of the left foot were three steps higher than those of the right. She does not know of the exact position of the extremity or whether the knee struck the floor. Since this injury she has been forced to walk with the knee straight and has had local pain.

Note of examination at this time was: "Patient is in good condition, walks with a limp on the left side with the knee held in full extension. She wears a bandage on the left knee. There is a small area of ecchymosis at the upper border of the patella. The patient is unable to hold the left leg extended against gravity when it is put in this position, nor can she voluntarily extend it. She can move the patella just perceptibly. There is a depression to be felt above the border of the patella, where there is local sensitiveness. There is slight local swelling."

Case No. 2. Photograph taken May 2, 1923. Patient standing, showing good tone in both quadriceps, three and a half months after operation on right knee.

Operation, June 22, 1922, Dr. Zadek. Ether anesthesia. An incision was made directly over the attachment of the quadriceps to the patella. The aponeurosis at the upper border of the patella was torn and the attachment of the quadriceps to the patella was torn away through its outer half, with a longitudinal split in the tendon itself, producing an "L" shaped tear. The covering of the patella was smooth and glistening. Above, there was a tear for a distance of one inch in the line of the quadriceps. The vastus internus was not torn completely free, some of its fibres still holding. The knee joint was opened as a result of the tear. There was no excess of

Case No. 2. Photograph taken May 2, 1923. Patient sitting, showing range of active flexion in both knees three and a half months after operation on right knee.

synovial fluid in the knee joint. There was a small amount of clotted blood but not as much as one would expect.

The quadriceps substance was united with mattress sutures of kangaroo tendon and the scarified upper border of the patella was approximated to the corresponding portion of the torn quadriceps with the same material, the lower sutures going through the substance of the patella. Subcutaneous catgut sutures, skin closed with catgut and plaster cast applied, extending from the ankle to the groin, with the knee slightly flexed.

July 12, 1922: Plaster was removed. The wound was completely healed except for one point of granulation about its middle. The quadri-

ceps could be felt to contract under the fingers and the patella just perceptibly moved with this contraction.

July 19, 1922: Patient was walking with crutches. Discharged.

January 17, 1923: Patient walked without limp. Photographs taken.

CASE No. 2. A. W., male, age 77, first seen January 6, 1923, at Mount Vernon Hospital. Service of Dr. J. J. Sinnott.

History. Yesterday patient slipped on the ice and in attempting to "catch" himself, in some way, the right knee became bent under him and he fell. He was unable to rise and was brought into the hospital.

Note of examination at this time was: "Patient lies with the right lower extremity in 30 degrees of outward rotation. There is swelling about the right knee. Most of this swelling is outside the knee joint. Patient lies with the knee completely extended. Attempts are made to get him to contract the quadriceps on the right, but he says he cannot do so. When the knee is passively flexed he complains of pain over its anterior aspect. He is unable to extend the knee voluntarily. There is a depression at the attachment of the right quadriceps to the patella and considerable local tenderness. There is no elevation of the trochanter. The distance from

Case No. 2. Photograph taken May 2, 1923. Patient sitting, showing range of active extension in both knees, three and a half months after operation on right knee.

the anterior superior spine to the internal malleolus on the right side is identical with the distance from the anterior superior spine to the internal malleolus on the left. There is moderate tenderness at the junction of the middle and lower thirds of the femur.

There is a nicely healed scar, four inches long, over the left knee with its middle over the upper border of the patella. Patient states that in 1912 he fell and sustained an injury to the left knee. Mount Vernon Hospital records show that he was operated on in 1912 for the laceration or tearing of extensor tendons from the patella of the left leg. The tendon was sutured to the patella.

Patient has a mild osteo-arthritis, affecting numerous joints, with an extreme degree of hallux valgus.

Radiogram of the right knee shows lipping of the bones of the joint, indicative of an osteo-arthritis."

Operation, January 18, 1923, Dr. Zadek. Under ½% novocaine an incision five inches long was made over the lower end of the right quadriceps. The vastus externus, rectus and intermedius were found completely separated from the patella. Some fibres of the vastus internus were found still attached to the patella. The tear exposed the interior of the knee joint. The exposed surface of the patella was smooth and covered with tissue resembling periosteum. Synovia of the joint was thickened and injected. There was an excess of synovial fluid present with very little evidence of old hemorrhage at the site of the tear.

The tendon was sutured to the scarified surface of the patella with mattress sutures of kangaroo tendon, and subcutaneous tissues were closed with interrupted catgut. The skin was closed with continuous catgut. Plaster cast was applied extending from the ankle to the groin with the knee in extension.

February 13, 1923: Plaster was removed. The wound was healed and there was good union of the tendon at the site of injury.

February 18, 1923: Patient could flex and extend the right knee from 150 to 180 degrees. Had no pain.

May 2, 1923: Photographs taken.

Summary of features common to these two cases.

1. History suggestive of underlying weakness. (a) The first patient sustained several injuries to the knee, each somewhat more disabling than

the preceding, until the last, which was fairly complete. (b) The second patient had sustained a similar injury to the left knee eleven years previously.

2. Local subjective pain at the site of injury is slight, and local pressure causes a very moderate amount of discomfort.

3. There is a depression just above the superior border of the patella into which one finger will fit transversely.

4. There is complete loss of power of extension of the leg.

5. There is no enlargement of the lower end of the proximal segment, but just a perceptible quiver on attempted contraction of the quadriceps, thus differing from the reported cases of ruptured quadriceps.

6. There is a strikingly slight amount of hemorrhage.

7. At operation the patella is smooth and covered with a periosteum-like structure (the patella, being a sesamoid bone, has no periosteum). Only part of the fibres of the vastus internus are intact. The joint is found open, exposing the intercondylar space of the femur.

8. The end result is complete restoration of function (incomplete in the second patient, due to an old arthritis) after operative suture.

A REPORT OF EIGHT CASES OF SEVERE CRUSHING FRACTURES OF THE OS CALCIS

BY WILLIAM L. SNEED, M. D., NEW YORK

Two types of operation with modifications have been used.

First case: A man forty years of age, weighing about 174 pounds, steam fitter by trade, was admitted to the Hospital for Ruptured and Crippled May 17, 1920, with a history of injury on September 29, 1919. He received an electric shock, fell off a ladder, striking on both heels. At the time he was admitted to the hospital he was walking with difficulty, using crutches. Radiogram shows severe crushing fracture of os calcis of both feet, also fractured astragali, impingement of external malleolus, with both feet in position of marked equinus. Examination showed that there was also a valgus deformity with stiffness of the toes and rigid flat feet. Operation: Lengthening of the Achilles tendon on both sides by the Z method, and a forceful correction of the before mentioned deformities. Both feet were put up in plaster at right angles and in slight inversion. Plaster remained on for six weeks, after which time patient was given baking and massage and manipulation. He was discharged from the hospital August 10, 1920, wearing Whitman braces; condition very much improved. Since that time, I have seen patient at intervals of several months. He walks very well, with slight limp in both feet; still complains of some pain just below the external malleolus, and I have advised that he have further operation, described in the other cases of this series, but so far he has not consented.

Second case: A man sixty-two years of age, weighing about 150 pounds, occupation stableman, was admitted to the Hospital for Ruptured and Crippled April 17, 1922, with a history of falling a distance of fourteen feet in 1918, striking upon the heel of left foot, and also sustaining a fracture of right tibia. He complained of pain below and anterior to external malleolus. X-Ray showed impingement of external malleolus on fractured os calcis. He was operated upon April 17th, 1922, and a curved incision 3½ inches long was made below and posterior to the external malleolus. The peroneal tendons were freed and excess callus removed from under the external malleolus until there was about ½ inch

distance between the tip of the malleolus and the bone below. There was considerable oozing of blood from the os calcis. The fibrous tissue was sutured, and then the skin. A small space was left at the lower angle of the wound to allow drainage, and to prevent a large blood clot forming, dressing was applied. May 8th the wound had healed by first intention, patient was discharged walking as well as when he entered the hospital; pain had been relieved to a great extent. He reported to my office until the middle of August, since which time he has been back at work at his former occupation of stableman.

Third case: A man 35 years of age, weighing about 145 pounds, occupation plasterer, was admitted to the Hospital for Ruptured and Crippled April 19, 1921. He was injured on September 4, 1920. He was treated by a private physician until January 15, 1921, after which time he made several attempts to return to work, but was unable to do so. He complained of pain below external malleolus and X-Ray showed impingement of malleolus on the os calcis. An incision was made parallel to peroneal tendons and below the external malleolus. Peroneal tendons were not dissected, as in former case. The excess callus was removed by chiseling under the peroneal tendons. As much bone as necessary was removed, then with a strong pressure of both thumbs the peroneal tendons and the remaining part of bone periosteum was pushed down into the excavation. In this way the impingement of the fibula was relieved. The wound was closed loosely and sterile gauze dressing applied. Patient was discharged from the hospital on May 11th. Wound healed by first intention. He walked with a slight limp and returned to my office for further treatment. He was discharged in June, still complaining of a slight amount of tenderness. He returned to Italy and has not been heard from since.

Fourth case: A man 42 years of age, weighing about 140 pounds, He was admitted to the Hospital for Ruptured and Crippled on December 20, 1921. Injured five months prior to being admitted. He fell 15 feet, striking on both heels, sustaining a fracture of both os calces. There was a marked protuberance below the external malleolus on both sides. This was quite tender, and he complained of pain below and anterior to the external malleolus. Flexion and extension of the ankle joint was practically normal. Eversion and inversion were absent. The same operation was performed as in case 3. Wound healed by first intention. Patient was

discharged February 17, 1921, walking without supports. Pain almost entirely relieved.

Fifth case: A man 44 years of age, weighing about 190 pounds, occupation factory foreman, was admitted to the Hospital for Ruptured and Crippled July 7, 1922. Three years previous in 1919, he fell a distance of 20 feet, striking upon the right heel. He had not been able to walk more than thirty minutes since accident on account of pain in the region of the os calcis. Principle points of tenderness under the heel, and just under and anterior to the external malleolus. Operation performed July 10, 1922. An incision parallel to the lower body of the os calcis was made. The under portion of the os calcis was exposed and two large spurs removed. The excess callus just under the external malleolus was chiseled away, the technique in case 3 and 4 being used. Wound healed by first intention. Patient was up and walking very well in four weeeks. Two vigorous massages were made at that time. Large hematoma formed under the os calcis and on the lateral side. This was opened up through the line of old incision. It took this about six weeks to heal. There was no infection present. Patient was discharged on December 19, 1922, still complaining of considerable pain. Under observation outside the hospital he walked without a cane on two different occasions for over three miles. We felt that this man was a malingerer, in order to obtain more compensation.

Sixth case: A man 29 years of age, weighing 230 pounds, occupation painter, was admitted to the Hospital for Ruptured and Crippled on January 8, 1923. He fell 20 feet, striking on his right heel. Excess callus just below the external malleolus was removed as in cases 3, 4, and 5. In this case there was marked limitation of motion in the ankle joint and foot was in a position of equinus. He also complained of pain just below but mostly anterior to the external malleolus. Same operation performed on this man as in cases 3, 4, and 5. Wound healed by first intention. He was discharged on February 5th. Has been under observation since that date. The motion now in the ankle joint is good and is only slightly restricted. He still walks with a cane but can walk for a long distance. Complains of some pain but is still unable to return to hard work.

Seventh case: A man 43 years of age, weighing about 160 pounds, occupation painter, was admitted to the Hospital for Ruptured and Crippled February 21, 1923. He was injured on January 11, 1923, by a fall of 20

feet. He complained of pain below the external malleolus and under the os calcis. X-Rays showed impingement of external malleolus on os calcis and spurs on os calcis. Incision 3 inches long was made on the outer side of right os calcis, parallel to lower border, tissues dissected and under surface exposed. Several small spurs found and removed, and the excess callus removed from under the external malleolus as in previous cases. Wound healed by first intention. Patient began standing on foot on March 8th, began walking on March 13th with the aid of crutches, was discharged on March 29th with practically no pain either on or under surface of heel or just under external malleolus.

Eighth case: A man 21 years of age, weighing 140 pounds, occupation elevator operator, fell five stories in June, 1922, landing on both heels. Radiograms taken showed marked crushing fractures of both os calces. Patient unable to stand six weeks after injury. Both feet stiff. Spasms in all muscles acting upon ankle joints and toes. Chief points of tenderness just under the external malleolus. Feet were forcefully manipulated, and both were operated upon; incision 3 inches long made on outer border of os calces. Excess callus removed under the external malleolus as in cases 3 to 7. Wound healed by first intention. Early manipulation was instituted. Patient began to stand on feet three weeks after operation. This man fell the greatest distance of any case in this series. He sustained very severe fractures of the os calces but had great recuperative power. Is quite stoical and ambitious. He can stand on his toes. Has normal motion on both feet with the exception of eversion and inversion. He is now filling a Civil Service position in New York City.

SUMMARY

In the series of cases presented there was one point in common: tenderness. In three cases there was also pain under the heel and tenderness. It is my opinion that when an os calcis is severely crushed by a fall upon the heel, and the astragalus is driven down into it, widening the heel and lowering the external malleolus so that it impinges upon the fractured os-calcis, changing fibula from a stay of the ankle joint into a weight bearing bone, for which nature never intended it, pain is produced. At least, it has in all the cases that I have seen. The subject of subastragaloid-arthrodesis has not been discussed in connection with these cases. I could not demonstrate any motion in this joint in any case of this series. In fact,

an arthrodesis had been performed by the severe trauma and nature's effort to repair it. We are not discussing fresh fractures, but I do not think it would be amiss to emphasize the necessity of more careful consideration and treatment of these cases immediately after injury. If they were properly molded, as has been advised by Cotton and others, most of these cases would not have needed operative interference. It was the persistent pain and tenderness of the first case in this series that first started me upon this investigation. I wish to emphasize the necessity of allowing for drainage when operating on these cases, as there is considerable oozing of blood. There is also one other point that I wish to stress: it is very difficult to show by radiogram the tunnel after it is made in the os calcis. I insist upon the patient bearing weight upon his foot at an early date. This is a necessary extra precaution so that dense fibrous tissue may not form and impinge upon the external malleolus.

A PROPOSED MODIFIED FUSION OPERATION ON THE SPINE.

A Combined Operation Producing More Rapid Ankylosis.

BY PHILIP LEWIN, M.D., CHICAGO.

Attending Orthopedic Surgeon, Cook County Hospital; Junior Attending Orthopedic Surgeon, St. Luke's Hospital; Assistant Professor of Orthopedic Surgery, Northwestern University Medical School.

This operation is a combination of the well-known fusion operation proposed in 1911 by Dr. Hibbs of New York City, and the osteoperiosteal graft proposed by Ollier of Lyons, France, and executed so successfully by Delagénière of LeMans, France.

The technique consists in

1. The classical fusion operation using the technique of Hibbs.
2. Placing of one or two osteoperiosteal grafts obtained from the tibia by the technique of Delagénière, in a bed of bone that has been denuded of its osteoperiosteal layers.

The purpose of the graft is not to produce a splint but to furnish all the elements necessary in the production of new bone and thereby effect a more solid early ankylosis, which is the desired result. The method is applicable to those conditions where solidification is indicated, as tuberculosis, fracture, and scoliosis, but especially in tuberculosis. The writer is unable to predict the result in cases of abscess in close proximity to the field of operation, but believes the procedure will be of value in spite of that contingency.

In a careful consideration of the principles laid down by Delagénière and in association with him in November, 1918, in operations on the long bones, jaw, and skull, it occurred to the writer that after a typical fusion operation on the spine there obtains a situation analogous to fracture of the radius and ulna with loss of substance, *i.e.*, in the spaces between the laminae, between the spines and in the articular facets. Of course in a well executed fusion operation, all these spaces are covered with bone that has been gouged out and carefully preserved as osteogenetic foci, but it is bone taken from the same area, and in the writer's

opinion of less osteogenetic power than is the osteoperiosteal graft taken from the tibia.

Advantages: The advantages presented are that there is produced a quicker and more complete solidification and there is a reduction of the danger of pseudarthrosis. It produces a continuous bony bridge across the posterior portions of the bodies and laminae.

The technique of a Hibbs spine fusion operation is quoted from his paper in the Archives of Surgery, May, 1922, as follows:

An incision is made through the skin and subcutaneous tissue, from above downward, exposing the tips of the spinous processes of the vertebrae to be fused. The periosteum over the tips of these processes is split longitudinally, and, with a periosteal elevator, pushed to either side, leaving them bare. The periosteum and interspinous ligament in turn are still farther split and pushed forward a short distance from each spinous process, as two lateral halves, gauze packs being inserted to prevent oozing. The dissection is carried farther and farther forward upon each vertebra, in turn, until the spinous processes, the posterior surfaces of the laminae and the base of the transverse processes are bared, thereby exposing the ligamentum subflava attached to the margins of the laminae and the articulations of the lateral processes.

The ligament is removed from the laminae with a curet, and the articulation of the lateral processes is destroyed in order to establish bone contact at this point. With a bone gouge, a substantial piece of bone is elevated from the adjacent edges of each lamina, of half its thickness and of half its width. The free end of the piece from above is turned down to make contact with the lamina below, and the free end of the piece from the lamina below is turned up to make contact with the lamina above.

Each spinous process is then partially divided with bone forceps and broken down, forcing the tip to come into contact with the bare bone of the vertebra below. The spinous process of the last vertebra below should be turned up to bring about contact with the next above. As the spinous processes of the lumbar region are wide, it is sometimes practicable to split them, turning one half up and the other half down. Thus is established contact of abundant cancellous bone at the articulations of the lateral processes, laminae and spinous processes. The periosteum and ligament, which together have been pushed to either side and lie practically as an unbroken sheet, are brought together in the

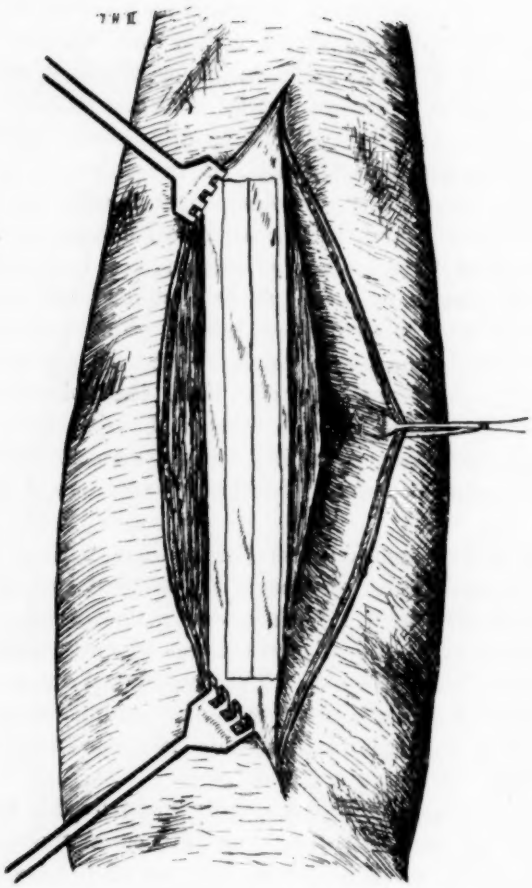

Fig. 1. The internal surface of the tibia exposed and grafts outlined, one along side of the other.

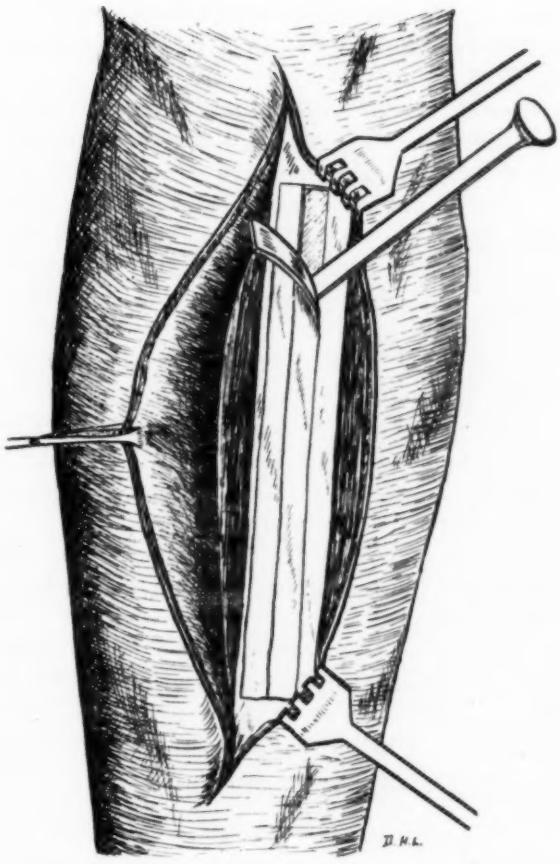

Fig. 2. Removing the graft by means of the chisel. The graft curls up as it is being removed.

middle with interrupted sutures of ten-day chromic catgut. The subcutaneous tissue is then closed with a continuous suture of plain catgut; the skin wound is closed with sutures of ten-day chromic catgut, and sterile dressings and an immobilizing brace or plaster are applied.

The technique of the osteoperiosteal graft is modified slightly from the paper of Delagénière and Lewin in Surgery, Gynecology and Obstetrics, May, 1920, as follows:

The graft is taken from the internal surface of the tibia, using a single bevel engraver's chisel, and a hammer or mallet. A long incision is made through the skin over the middle of the internal surface of the tibia, without cutting the periosteum. The latter is exposed thoroughly and the grafts are outlined with a scalpel. (Fig. 1.) Each graft may be removed separately or one full width graft removed and cut longitudinally with a heavy surgical scissors. The size of the graft is determined by the area to be covered. Following the outline, the grafts are removed with a chisel. The bevel is kept high and the cutting edge firmly against the bone. By varying the inclination, one obtains the proper thickness, which is approximately that of a ten-cent silver coin. When the graft is removed it is placed in a compress and immediately transplanted into the wound of reception, which has been thoroughly prepared previously.

Emphasis must be placed on the fact that the operation is one part of the cure and that the mechanical fixation and treatment is still of paramount importance.

The writer believes that the osteoperiosteal graft, first recommended by Ollier and accentuated and established firmly by Delagénière, is the most efficient bone producer at the present time. If we could produce a hypertrophic arthritis limited to the affected area it would be ideal. This method is the nearest approach to it.

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ARM-CHEST ADHESIONS.

Brachio-thoracic Adhesions, Axillary Webs.*

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INTRODUCTION.

When the Chairman of your Programme Committee asked me to address the American Orthopedic Association it occurred to me that it might be interesting to consider a group of cases dealing with the function of the arm, so I have chosen as a subject, arm-chest adhesions.

The purpose of this paper is to call attention to the proper treatment of these adhesions, and it is based on a review of the literature and on a study of 48 cases hitherto unreported. These may be divided as follows: 25 patients operated on in the surgical clinic of the Johns Hopkins Hospital, by 15 operators; 2 at the Children's Hospital School, by 2 operators; 14 on whom I have operated, and 7 patients who have come to me for consultation, 2 of whom are now awaiting operation.

The deformities caused by these adhesions, in extensive cases, are among the most serious with which the plastic surgeon has to deal. The affected arm is practically incapacitated and in young people growth and development is retarded. A disagreeable and not unimportant accompaniment is that the patient is frequently unable to wear ordinary clothes.

I have heard it said that there is no excuse for the occurrence of such adhesions, and that the presence of an axillary web indicates poor treatment. Theoretically this is true, but when one is called upon, either in the home or in the hospital, to deal with an extensive third degree burn of the arm, axilla, chest wall, and probably other regions of the body, where the condition of the patient is extremely critical, and for a considerable time it is doubtful whether life can be saved, unquestionably it is better to allow the patient to assume the most comfortable

*Read by invitation at the meeting of the American Orthopedic Association, held in Rochester, N. Y., June 7-9, 1923.

position and thereby add a little to the chance of saving life, rather than increase the pain and shock by insisting on what is known to be the best posture for the prevention of adhesions. When patients with axillary webs come to me I never feel justified in criticizing the early treatment, as the man on the spot may have been called upon to make some such decision as I have mentioned above, and may have done splendid work in pulling the patient through at all.

HISTORY.

The literature for the last twenty years shows an occasional case report but little else. The principal contributions were made in the last half of the last century by French authors, among them Jobert, Verneuil, Berger, Defontaine, and Piéchaud, and their conclusions were based on the study of one or, at most, two cases each.

About the middle of the last century, it was recognized that cicatricial tissue could be used in the repair of deformities due to scar contracture, provided that it was flexible and that it had sufficient vascularity. Based on this fact, several operations have been devised utilizing the scar web itself, either in whole or in part, for the correction of the deformity. It seems quite remarkable that more has not been written on the subject, and that so little is apparently known about the treatment.

ETIOLOGY.

It is interesting that an axillary web may be congenital in origin. This is very rare, however, the case reported by J. B. Manson in the London *Lancet* being the only one I have encountered in the literature. Dr. Whitridge Williams tells me that no such deformity has occurred in the obstetrical service of the Johns Hopkins Hospital.

The vast majority of the arm-chest adhesions considered here, and also those reported elsewhere are the result of third degree burns where the granulating surfaces are allowed to come in contact with each other and eventually fuse. Arm-chest adhesions are not at all uncommon in this section of the United States, but I understand that these cases are found more frequently in countries where crude methods of heating, cooking, and lighting still prevail. Dr. Arley Munson writes me that he treated numbers of these adhesions in the course of his surgical work in India, and Dr. Eleanor Wolf Stewart tells me that she also had a similar experience. Most of these patients were children who had been

burned by the primitive open lamp of India, which is usually placed on the floor when lighted.

SUMMARY OF CASES. — TOTAL NUMBER, 48.

Cause: burns with fire, 44; burns with hot grease, 1; X-ray burn, 2; slough of breast flap, 1.

Age in decades: first, 28; second, 10; third, 4; fourth, 2; fifth, 3; sixth, 1.

Sex: male, 23; female, 25.

Side involved: right, 28; left, 17; both, 3.

Time elapsed since injury: Under 2 years, 30; up to 10 years, 13; ten years or over, 5. Many types of webs have been found, and no two have been exactly the same.

Cases operated on: 41. Types of operative procedures may, in a general way, be grouped as follows:—

Excision of binding scar with suture, 4; *transverse division with vertical closure,* 3; *division or excision of the binding scar with autoplastic operation,* 34. *Complications:* erysipelas, typhoid fever, diphtheria, bronchitis, slough of flaps (partial or complete), partial break down of suture line, partial take or failure of skin grafts, partial recurrence of binding scar. *Secondary operations:* 18. *Results:* well, 25; improved, 16.

Analysis of cases:—Forty-four out of 48 were caused by burns with fire. In every one of these there was more or less extensive scarring in addition to the arm-chest adhesions. The ages varied between 4 years and 59 years, there being more cases in the first decade than in all the rest together. The sexes are about evenly divided. White patients predominate, 42 to 5, which is about the proportion of white to colored in Baltimore. Thirty-two patients were examined under two years after injury; 22 of these under one year. Of the remainder, in one the adhesions had been present 2½ years; in five, 3 years; in one, 3½ years; in two, several years; in one each, 6, 8, 10, 12, 13, 21 and 57 years. The shortest period was several months, the longest 57 years. In the types of operations mentioned, for convenience I have placed

under autoplastic operations, 34 cases. As a matter of fact, each one of these might be grouped separately, as while they may be listed under the same general heading, the actual operative procedures differed widely.

In arm-chest adhesions, result: "well," on the hospital history may be misleading, as subsequent investigation often shows that "improved" would be the maximum that could be claimed. On the other hand, after the relief of the binding scar and forming the axilla, what is "improved" at discharge may with time and proper manipulation develop into a good result.

Types of adhesions. Axillary webs vary markedly in type, from the thin lax membrane which allows considerable motion to the solid thick mass of scar tissue which obliterates the armpit and glues the arm immovably to the chest wall. These adhesions may vary in extent, from a few centimeters to the full length of the arm. The entire axilla may be obliterated or the adhesion may be along the anterior or posterior axillary fold, or both. There are numerous degrees of the deformity, each one of which demands special study, if the best result is to be looked for. The amount of motion possible for the arm and shoulder depends on the vertical length of the web and on its shortness transversely. In other words, the longer the vertical length and the shorter the transverse measurement, the less the motion.

Anatomic changes. The anatomy of the parts involved may be materially modified by these extensive deep cicatrices, and great care must always be exercised when the arm is abducted after division of the adhesions, lest damage may be done to some deep vessel, important nerve, or even to the humerus itself. In cases of long duration, there is frequently marked atrophy of the bones (humerus and portions of the scapula) and also of the muscles and other soft parts, due to disuse, with the additional factor of pressure from thick unyielding scar. The atrophied arm is thinner and in some cases the humerus is shorter than in the normal arm. The head of the humerus may be pulled forward by the scar. Underdevelopment of the glenoid cavity and acromion process is occasionally found, due to lack of use and continued scar pressure. Often there is contraction of the muscles and of the muscle aponeuroses. Sometimes there is replacement of the muscle tissue by scar. In practically all cases with extensive adhesions between the arm and chest wall, there is marked scoliosis, and this cannot be

corrected in any way until the adhesions are released and the scar tension is relieved.

There is distinct limitation of chest expansion on the affected side and occasionally the ribs are deformed. In the majority of cases the burn involves a considerably larger area than the axilla and adjacent portions of the arm and thoracic wall, and in consequence we frequently find other contractures, such as those of the neck and face, the cubital space, forearm, wrist, etc., etc., which may complicate the operative procedure. In several cases, which have come under my observation, both axillae have been involved with more or less extensive webs. Not infrequently we find dense keloid growths complicating the condition, and I have seen the binding scars entirely keloidal in character.

Preliminary care. Every effort should be made to build up the general health of the patient before operation and to raise the hemoglobin to at least 75 percent. The building up process may be a very slow one in badly depleted cases, but during this period if any unhealed area is present, the wound and surrounding tissues can be carefully prepared for future operative work.

When handling children, and many of these patients are children, one must use every effort to gain their confidence and do the dressings without pain. This may seem a minor point, but I have seen children nearly frantic with dread of the next dressing when the last one had been inconsiderately done. This mental attitude tends to keep the patient below par and makes it more difficult to build him up.

When the web has formed and the scar is rigid and adherent, unless directly contraindicated, I frequently advise a month or two of systematic massage of the entire scarred area, with carefully directed stretching and passive motion. In this way, the circulation is improved and tissues are softened and can be utilized in the operative work which would otherwise have been entirely unavailable. Keloidal scar may also be made softer and more pliable by careful treatments with radium or X-ray, and in certain cases such treatments are worth a trial before operative work is commenced. I have had no success whatever with fibrolysin.

Preparation of the part for operation. Sponge the field with alcohol followed by ether; then paint with two or three coats of one-third strength tincture of iodine (stronger iodine is inadvisable on scar tissue). Another excellent method is to paint with a 5 percent. alcoholic

solution of picric acid, after sponging with alcohol followed by ether, and this has the advantage of being non-irritating, although its staining properties are objectionable.

Anesthesia. General anesthesia (preferably with ether, or gas-ether) must be used in the majority of instances, because where one is dealing with scar, or scar infiltrated tissue whose power to heal is already doubtful, the use of a local anesthetic by the infiltration method is questionable. In this tissue, resistance is lowered and the scanty circulation is interfered with by the infiltration, and sutured wounds do not heal as kindly as they would without it. I, therefore, hesitate where primary union is essential to use infiltration, but where simple division of the adhesions, or excision of the binding scar without immediate suture is called for, the method can be used to advantage. Nerve blocking, while possible, is a considerable undertaking for operations of this character and cannot be recommended. I use for infiltration 0.5 percent novocain or procain, with from 5 to 10 drops of adrenalin chloride to each 30 cc.

Sutures and ligatures. In all of these cases I prefer catgut for ligatures and buried sutures. While silk can be used with impunity in wounds which we know are clean and where normal tissue is being dealt with, I find it safer to use the absorbable material in scar infiltrated tissue, which not infrequently breaks down. For closing the skin I prefer horse hair and the "on-end" mattress suture. Fine waxed silk is also useful. For tension sutures, silk worm gut or silver wire give the best results.

All wounds should be sutured without tension, if possible, and tension sutures should be the exception rather than the rule. Where sutures are placed in scar tissue they should be fairly far apart and should not be tied too snugly.

Asepsis should be maintained throughout the operation and until healing is complete. Tissues should be handled with the greatest consideration, and this applies especially to pedunculated flaps. All hemorrhage should be carefully checked and the area into which the flap or graft is to be transferred should be perfectly dry, as many failures follow the formation of a clot beneath the transplant.*

Small protective drains inserted at strategic points under the flap, and removed within 48 hours, are often advisable.

*In this paper when I use the term *graft* I mean a free transplant, and when I use the term *flap* I mean a mass of tissue which is attached at some point of its periphery or base by a pedicle through which it receives its blood supply, and which can be shifted as far as its pedicle will allow.

TREATMENT.

Much has been said concerning the relief of arm-chest adhesions by means of local treatments and various methods of extension, but my experience has been that after the web has formed and contracted fully, except possibly in the slightest grades, nothing promises permanent relief except properly executed surgical intervention.

When healing is not complete. I will not consider the preventive treatment, inasmuch as the plastic surgeon is seldom called to these cases until adhesions have formed and the arm and chest wall are bound together. Sometimes, however, we do see patients reasonably soon after adhesions have formed, but before healing has taken place. In such cases, the granulation tissue should be brought into satisfactory condition by the use of Dakin's solution or some other effective treatment, checked by bacterial count. Then, under a general anesthetic, all granulations are curetted off, and it is usually found that the arm can be pulled away from the chest wall without much difficulty and that a definite line of cleavage develops which extends to the top of the axilla. If this does not occur at once, divide all binding tissues until the arm is free, then raise the arm at least as high as the shoulder, and higher if it is deemed advisable, and secure it in this position. This may be all that can be accomplished at this time, but frequently it is possible to proceed with skin grafting or flap transplantation at once. The use of these methods will be considered later.

Patients occasionally come in with dense adhesions of long duration (several years) but with healing still incomplete. In these instances as soon as the granulations are properly prepared, epithelization is hastened by means of small deep grafts, and after the lapse of several months, during which time massage is inaugurated, the operative work should be commenced.

Division of the adhesions. It is probable that the first operative procedure practised for the relief of arm-chest adhesions was simple division of the web across the binding portion down to normal tissue. Packing the gaping wound thus made, and keeping it packed until healing by granulation finally took place was a later development. Simple division may improve conditions somewhat, if the arm is kept fully abducted during the period of healing, but the method is not to be recommended, inasmuch as it is slow and uncertain, and other procedures are better.

Excision of the binding scar. Occasionally the contracting portion of the scar is of such a character that it should be excised and the defect grafted. Sometimes instead of grafting, it is possible to close the defect by suturing, after undercutting and gliding. If this is done it may be necessary to make relaxation incisions in order to bring the edges together without tension. These incisions should be made a sufficient distance from the edges to be sutured, in such a way as not to interfere with the blood supply. The defects left by the relaxing incisions may be grafted at once, or subsequently.

Division and suture of edges in lax webs. When the web is lax and fairly thin the adhesion may be relieved by dividing transversely through the scar down to normal tissue and suturing longitudinally. Considerable gain is often made by this procedure. Another method is to make a sinuous incision, or an angled Z-shaped incision or some modification of it, shifting the flaps thus formed and closing so as to lengthen the binding edge of the web. The difficulty with this plan is that the flaps may slough and the suture line break down, as the operative procedure is carried out in scar tissue where the circulation is precarious. Although some gain is usually made, recurrence at least to a certain extent will invariably follow unless the operation is done with more than ordinary skill. These methods may be useful in selected cases and should be kept in mind.

"V"-incision with "Y"-closure. The method which Wharton Jones used for the relief of ectropion was employed by Verneuil in 1857 on one case twice in two places, and he reported a good result.* The procedure is as follows:—A "V"-shaped incision is made in the selected portion of the scar band down to healthy tissue. The surrounding tissues are undercut and the flap loosened and pushed up or down as the case may be, and the closure is made in the shape of a "Y." Some gain can be made by this operation, but for the permanent relief of a contracture in this position, unless it is of minor degree, it is seldom successful. However, this method may be used with success in certain secondary operations and should not be forgotten.

Formation of an epithelial lined fistula. In lax, very thin webs, the formation of a cicatrized fistula high up in the web, based on the method

*This patient was seen some years later and further operative work was required.

suggested by Rudtorffer in the treatment of syndactylism in 1801, has been used. To accomplish this the web is perforated as high up as possible and a glass or rubber tube, or some smooth foreign body is introduced and secured in the opening. After healing is complete, the web is divided up into the fistula, and the lateral edges are closed by sutures. A good axilla can never be formed by this method alone and simple perforation in my opinion is an undesirable procedure. If, however, this type of operation is chosen, a better method, based on Félizet's procedure for syndactylism is as follows:—A pedunculated flap of skin and subcutaneous tissue of the desired size, with pedicle *above*, is raised from the highest portion of the web on the front or back, depending on which side the skin is least infiltrated with scar. A similar flap, with its pedicle *below*, is raised from the other side of the web. Any soft tissue which remains after raising the flaps is excised. Then the flaps are drawn through the opening and sutured so as to line the fistula as completely as possible, a piece of gauze fitting the opening snugly is wrapped in rubber protective and drawn through, and then dressings are applied. When healing is complete, the web is divided up into the fistula, and the lateral edges are sutured.

SKIN GRAFTS.*

In certain instances where the scar is so deep and so widespread that there is no available adjacent tissue, the only solution of the problem seems to be by the use of skin grafts. After the adhesions have been released and the arm abducted and secured, the grafts may be applied either immediately, which is advisable if the tissues are in good condition, or within a few days after granulations have formed, if there is marked atrophy of the soft parts. Three types of grafts are available for this purpose.

Small deep grafts, which are the least effective for the lining of the axilla, because there is more scar tissue formed between these grafts than in other types, and consequently more subsequent contracture. However, this type of graft is effective in filling in raw surfaces on the chest wall and arm, and may be very useful as a temporizing procedure in the axilla.

A much more satisfactory type of graft for this purpose is the large, thin Ollier-Thiersch graft. The axillary space can be completely cov-

*Technic of Skin Grafting, "Plastic Surgery," J. S. Davis, p. 49.

ered with one or more of these grafts and also all other raw surfaces as well. The subsequent contracture is much less than when small deep grafts are used, and a high and in some instances a well-formed axilla can be made. Recontracture, especially along the anterior and posterior axillary folds, is prone to occur, but can be relieved with comparative ease by appropriate secondary operations.

The best type of graft to form the axilla is the whole thickness (Wolfe-Krause) graft. It is obvious that an axilla lined with skin of full thickness which is soft and has the qualities of normal skin, and which has little tendency to contract is better than either of the types previously mentioned. On account of the greater operative procedure and comparative unfamiliarity of most surgeons with this type, whole thickness grafts have been used very infrequently for lining axillae. Sometimes it is advisable to form the apex of the axilla with whole thickness grafts and cover the other raw surfaces with either Ollier-Thiersch or with small deep grafts.

PEDUNCULATED FLAPS.

When the axilla is obliterated, and the upper portion of the arm is bound to the chest wall, numerous methods of utilizing flaps to reconstruct the armpit have been described.

Depending on the condition of the surrounding tissues these flaps may be composed of scar or scar infiltrated material, of scar and normal tissue, or entirely of normal tissue. The latter is, of course, to be preferred, if available.

Flaps which are composed partially or entirely of scar tissue:—Berger's operation, 1887:—Berger devised an operation in which he split the web and readjusted the flaps, somewhat after the method used by Didot for syndactylism. His method is as follows:—Along the lower margin of the web an incision is made following the centre of the fibrous arch joining the arm and the chest wall, thus separating the web into two planes, one anterior and the other posterior. The separation is carried up between the planes to the apex of the axilla and out on the sides as far as necessary. The anterior plane is then raised and separated from the trunk by an incision which follows its line of junction with the thoracic wall and extends to the top of the axilla, thus making a triangular flap with its base along the arm. The same procedure is carried out on the posterior plane, the incision on this

side being made along the arm, the base of the flap being along the chest wall. The arm is then raised and the flaps are shifted, the anterior to cover the raw surface on the arm, and the posterior flap to fill in the loss of substance on the chest wall.

Berger says that this method can be used with success in the majority of instances. I cannot agree fully with this statement but I have found it satisfactory in certain cases where the web is lax, but inasmuch as the flaps are composed entirely of scar tissue they are liable to slough, at least in part. However, if only a part of each flap retains its vitality, the condition may be materially improved and by secondary operations full function can eventually be restored.

Defontaine's operation, 1892:—Defontaine (du Creusot) devised an operation based on a modification of the principle used by Félizet for the formation of a commissure between the fingers. This can be done either by the use of square flaps, or angular flaps united obliquely, which latter he prefers. He makes a vertical "Y"-shaped incision on front and back, the arms of which begin in the normal skin just above the level of the apex of the axilla and meet at about the middle of the web. The "V"-shaped flaps included between these incisions are dissected up, and the "Y" is completed by dividing the web in its midline. All adhesions are then separated and the arm is raised. The flaps are then turned in to form the axillary commissure, the anterior being inside and the posterior outside, and the edges are sutured meeting each other obliquely. All raw surfaces are then filled in as well as possible by suturing. It must be remembered that even under the most favorable conditions the tip and central part of each flap is composed of scar tissue whose circulation is doubtful. Moreover, the closure of raw surfaces by shifting tissues is difficult unless the surrounding skin is in fairly good condition. However, skin grafting can be used to fill in these defects.

Piéchaud's operation, 1896:—Piéchaud raises two large triangular flaps, the anterior with its base in the pectoral region and the posterior with its base in the scapular region. The free ends of both include a portion of the web. All adhesions are divided and the arm is raised. The flaps are then turned in to form the axilla, the anterior flap being above the posterior (when the arm is fully abducted). All other raw surfaces are covered by suturing the edges. This procedure is an improvement over that of Defontaine as the flaps are larger and the blood

supply is better. This operation also depends for its success on the presence of normal skin adjacent to the web.

Flaps which are composed of normal tissue. Jobert's operation, 1849: —Jobert (de Lamballe) seems to be the first to have perceived the necessity of lining the axilla. In his operation, the web is divided and the arm is abducted. A transverse flap of sufficient length and breadth is raised from the chest wall above the breast with its pedicle above the axillary fold, and is turned to line the axilla. It is sutured into place and all other raw surfaces are closed, if possible. Skin grafting, which was unknown at that time, is very useful for covering the raw surfaces which cannot be closed by suture.

Chaput's operation, 1904:—Chaput's operation is similar to that of Jobert except that a vertical flap is raised from the skin of the breast and chest which has its pedicle above on the level with the top of the axilla.

Berger's operation, 1904:—Berger, in extensive cases in which the splitting of the web will not answer for the formation of the axilla, utilizes in women a very similar flap to that of Chaput, but in men secures his flap from the scapular and subscapular regions with its base above, on the level with the apex of the axilla. In all of these operations, the adhesions are divided and the arm completely abducted before the flap is turned in to form the axilla. Theoretically all of these methods can be used if normal tissue is present, but if there is extensive scar involvement on the chest wall, both front and back, the success of such flaps is far from sure.

Croft's operation, 1884:—Croft was successful in relieving an extensive lax axillary web by delayed transfer, using a double pedicled flap of skin and subcutaneous tissue, 8x2.25 inches, raised from the deltoid region and arm. The lower pedicle was divided after 16 days and the free end of the flap was shifted, being turned on its upper pedicle and sutured into the defect made by the division of the web down to healthy tissue beneath. He emphasized the fact that the flap should be "taken free of scar tissue and well supplied with blood." Inasmuch as there is frequently extensive scarring of the arm and shoulder, this method can be employed in very few cases, but even in those, if normal tissue is available in the pectoral or scapular regions, flaps from these are preferable for forming the axilla.

Personal preference:—I have found that when we have a lax web involving the anterior or posterior axillary fold, or the axilla itself, one of the operations mentioned above for lengthening the binding edge, or transposing scar flaps to line the axilla may be used with success. If normal tissue is available, the web may be divided or excised, at least in part, and the continuity of the scar be broken by gliding in normal tissue to fill the gap. I might say that in many cases of scar lengthening secondary operations are required to relieve post-operative contracting bands.

When the adhesions are thick and obliterate the axillary space, my experience has been that the use of pedunculated flaps is the procedure of choice. A single flap either from the chest or scapular region, with its pedicle above, may be sufficient to line the axilla. Two flaps, one from the front and the other from the back, are usually required, the free ends being sutured together. Occasionally it is advantageous to form the axilla with a flap having a pedicle of subcutaneous tissue. The type, shape, and size of the flap must necessarily vary according to the condition and location of available well vascularized tissue.

When there is absolutely no tissue available for flaps, and grafts are considered inexpedient or have failed, then one must think of shifting a flap from a distant part by "successive migration." For instance, a tube flap of the desired size can be raised wherever the tissue is available—one end is eventually grown into a prepared defect on the normal forearm or wrist. In due time, the other pedicle is cut, the web is divided completely and the forearm with the flap is brought across the body and immobilized, and the free end of the flap is sutured into the desired position to form the axilla. Subsequently the flap is cut away from the forearm and the pedicle is utilized where needed. This is only one of many maneuvers to accomplish the same purpose.

In cases where the surrounding tissue is unsuitable for the formation of flaps, skin grafting must be resorted to.

DRESSINGS.

It is difficult to recommend any single type of dressing after these operations, as this depends largely on the operation performed. In the majority of instances the arm is abducted at least as high as the shoulder, and in some over the head, and it is usually immobilized by means of a suitable splint or plaster cast.

If the operation has been readjustment of the binding scar with suture, then any of the ordinary wound dressings (such as silver foil) can be used. If there has been a reconstruction of the axilla with flap shifting, or skin grafting, or both, we must use some type of dressing which will hold the transplanted tissues in absolute contact with the new bed and insure a high axilla. A single thickness of vaselined gauze over the newly formed axillary space, a moist sea sponge cut to fit the cavity and over this gauze properly secured, is a good way to obtain contact of either grafts or flaps here or elsewhere. Grafts on the arm or chest wall may be secured by rubberized or paraffined mesh over which is placed any dressing desired, and the whole immobilized by adhesive plaster and crinoline bandage. In some instances, when the new axilla is formed of flaps with good circulation, the space may be filled with a sea sponge, or gauze as suggested above, and after proper dressing of sutured or grafted areas on arm or chest, the elbow may be lowered and immobilized as in a radical breast case.

POST-OPERATIVE TREATMENT.

The patient should be placed on an adjustable bed in the most comfortable position possible. The dressings should be done by the surgeon himself or under his direct supervision, as good results in a large measure depend on skillful and judicious after-treatment. The type of dressing and the materials used vary according to the requirements of the wounds.

Flaps should be inspected frequently in order to relieve dangerous tension, combat infection, or to evacuate any fluid which may collect. If congestion of the flap occurs, it can best be relieved by gentle stroking with the finger tips *towards* the pedicle. Sometimes this must be kept up continuously for the first few hours until the return circulation is established. Small wet cups will occasionally aid in saving a congested flap. Warm normal salt solution compresses, at a temperature which will be quite harmless on the normal skin, will often cause blistering of a flap and must be used with care. If no circulatory disturbance occurs, the flap is treated as any other sutured wound. I usually begin to remove the stitches on the fifth or sixth day, and have them all out by the tenth or eleventh day.

If skin grafts are placed on a fresh wound and there is no apparent trouble, it is not necessary to disturb the dressing for a week or ten

days. If on the other hand, the grafts have been placed on a granulating surface, they should be dressed in 48 hours, and every day thereafter until healing is complete.

In those cases where the arm is put up in the abducted position at the operation, it should be held in this position until healing is complete, then it should be gradually lowered to the side, and passive motion and massage commenced. The coöperation of the patient is essential in the various stretching exercises in order to get the full benefit of the treatment.

During the day, the arm may be allowed to hang at the side, but at night for a period of several weeks, it is advisable to have it returned to the abducted position. In those cases where the arm has not been put up in the abducted position at operation, as soon as healing is complete, abduction must be gradually obtained, and at night the arm should be secured in the abducted position as mentioned above. This maneuver, while irksome, will in the end save time and prevent recontracture.

In extensive cases of long duration, where there has been atrophy of the bone and soft parts due to disuse and scar pressure, after the release of the adhesions the shoulder, arm, and forearm have to be practically reeducated. Considerable time may elapse before full function can be restored, but this can be shortened materially by massage and passive motion. In some instances, the natural contours are never restored, and the humerus never attains its full development, although function is apparently normal.

COMMENTS.

The operator who has had little dealing with scar tissue contractures and adhesions frequently underestimates the liability of recurrence, and is inclined to use procedures when relieving webs which a more experienced man knows to be inadvisable. The choice of the best procedure in many instances is not easy.

The treatment of arm-chest adhesions would be comparatively simple if we always found the skin adjacent to the web to be normal or even slightly infiltrated with scar tissue. The division of adhesions and the release of the arm from the chest wall as a rule is more or less simple, but the prevention of the reformation of the adhesions may be difficult.

The treatment of these cases is not a cut and dried affair, as each deformity presents certain difficulties which are not found in others. Each case must be worked out on its own merits; the methods chosen for its relief depending on the condition of the surrounding tissues, the extent and type of the web, etc. The contemplated plan of attack, based on the ultimate result desired, must be carefully studied. The size and shape of the flaps should be definitely determined and marked out, as well as the lines of incision.

If the vascularity of the flap seems adequate then it may be shifted at once, but if it is doubtful, delayed transfer should be chosen. The pedicle of a flap may be either above or below the level of the axilla, depending on the condition of the surrounding tissues. For instance, in front the pedicle may be above, and in the scapular region below, or vice versa. Sometimes the flap lifted to form the axilla proves to be too short to completely line the space, and no tissue is available for a second flap to suture to it. The deficiency may be filled at once by a skin graft, preferably of the whole thickness variety, but if this is unsuccessful the flap may be further utilized as follows:—After healing is complete it can be raised again and will be found to stretch considerably further than was possible when it was first transplanted, without jeopardizing its circulation. Another method is to divide the original pedicle, and slide the flap on its new base.

In dealing with these cases, a knowledge of the resistance and utility of tissues more or less infiltrated with scar is essential, as normal tissue is usually unavailable.

There is frequently astonishing retraction of the tissues after division of the cicatrix, as the scar itself retracts and the stretched normal skin attached to the scar also retracts. When the scar is widespread and deep, the problem is much more complicated, and flaps must be shifted in from parts at a distance, or skin grafts must be used.

The surgeon undertaking these cases must be skilled in the technique of skin grafting and be able to utilize any type which may be necessary, as skin grafts are used in some stage of the operative treatment in the large majority of cases. All the principles of tissue shifting and of the use of pedunculated flaps must be at the beck and call of the surgeon, as "every trick in the bag" may have to be used to secure a successful result.

In extensive cases of long duration, with immobilizing adhesions and much atrophy of the bones and soft parts, it is safer not to raise the arm higher than the shoulder at the time of operation on account of possible injury to vessels, nerves, or even to the humerus itself. Full abduction can easily be obtained later, after the tissues have stretched.

In each of several extensive cases I have found a rigid, thick, depressed band of scar on the outer side of the arm about on the level with the insertion of the deltoid muscle. This contracts transversely, markedly compressing the soft parts beneath it, and seems to actually grasp the shaft of the humerus. It is expedient to divide this band longitudinally down to normal tissue, extending the incision well above and below the stricture, whereupon the incision gapes widely and the soft parts bulge out when relieved of the scar pressure. This area is then grafted immediately, if the appearance of the atrophied tissues warrants it, otherwise in a few days when the circulation is improved.

Sometimes we find patches of comparatively normal hairy axillary skin drawn by the scar entirely away from its original bed, or it may be buried in a deep pocket in the scar, which has a rigid purse-string like opening. If possible, this skin should be utilized and replaced in its normal position.

After the operative work has been completed, the healed area may present an irregular patchwork appearance. This is of little importance, however, if the axilla is reconstructed, if scar pressure is relieved, and if function is restored. It may be necessary to divide muscle aponeurosis and muscle tissue when contracture is marked, and abduction cannot otherwise be obtained. If subcutaneous fat is available it is advisable to shift it under suture lines, especially if the skin is infiltrated with scar. In certain severe cases I have found it advantageous to do the operative work in stages, planning for the patient to go home between the steps, in order that nature and time might aid as much as possible.

The operative methods and suggestions mentioned are useful in the treatment of these cases, and either alone or in combination may be helpful in the solution of problems, some of which require all the skill of the surgeon to solve. The patient should be warned of the possibility of more than one operation being necessary to effect a cure. These cases should be followed up systematically after discharge from the hospital, and should report for examination at least every three months until final discharge.

CONCLUSIONS.

Arm-chest adhesions are not uncommon.

In the majority of instances they are the result of third degree burns.

The object of the treatment is primarily the restoration of the function of the arm, with the relief of the deformity, and the prevention of recurrence. The successful reconstruction, or readjusting, of the axillary space (armpit) is the key to the relief of the condition.

There is no single operative procedure which is applicable to the treatment of all types of axillary webs.

It is seldom that the deformity, if in any way extensive, can be relieved by one operation,—in fact, in nearly all cases several operations are necessary to completely restore function, and in each one of the secondary operations new problems are presented which may require different methods of attack.

The only test of the efficiency of any of the operations used for the relief of arm-chest adhesions is *time,* and the ultimate result should not be recorded until at least one year has elapsed after the final operation.

SUPPLEMENTARY NOTE.

Ollier deserves the credit for the originality of the osteoperiosteal graft. His results were not favorable for two reasons,—viz.: firstly, he used too thick a graft, and secondly, his wounds become infected. To Delagénière belongs the credit of putting it on a sound basis, outlining the indications, standardizing the technique, and reporting the results of 273 cases. During the war the three ardent advocates of this type of graft were Delagénière, Chutro, and Dujarier. (As a supplement to the massive bone graft in the repair of fractures of the long bones, the writer recommends very strongly the use of the osteoperiosteal graft.)

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DISCUSSION ON PAPER OF DR. DAVIS.

DR. H. L. PRINCE, Rochester, N. Y.: There is not much to discuss in a paper of this kind. I know of no field in surgery where cases have to be so much individualized and I know of no branch of surgery where the results, when you get them, are more satisfactory or are so often interspersed with bitter disappointment. If the patients have courage and perseverance most of them in the end can be gotten into very good shape, but it is distressing to see the best planned schemes break down and fail. Sometimes it is just a matter of luck, where the question of judgment has no chance.

The important thing to me is the aversion of the profession to resort to skin grafts early. Generally there is the feeling that skin grafting is to be avoided. I think the faith which rose in the paraffin dressing treatment is responsible for a good many bad deformities. It is true that epithelium spreads well under paraffin, but the idea that the whole skin spreads over under paraffin still holds with some people. While there are cases in which the epithelium spreads over very well, I have seen cases in which motion was entirely lost because of this treatment and the patients would have done so much better if a few skin grafts had been put in early.

I think Dr. Davis' work is very valuable to us all because he has pointed out to us that we can utilize soft scar tissue to advantage.

DR. JOHN RIDLON, Chicago, Ill.: For the sake of the record in the publication of this paper I want to call attention to the fact that some twenty years ago I reported three cases under the title of "Multiple Congenital Deformities." In one of these cases there was a bilateral webbing of the axillae. That has been overlooked in the preparation of this paper. Nothing was done for the axillae in my case because the child had a bilateral club-foot, a bilateral recurvation of the knees, bilateral club-hand, and flexed and stiff elbows. When we had the feet and hands corrected we thought we had done enough.

One point which I think the writer of the paper should have underlined a little more heavily was the treatment of burns at the time they occur. If these cases had been treated with the arms in an ideal position the contractures would not have occurred as they did. I think in the publication of a paper of this kind it should be carried to the profession that when a burn of this kind occurs that is likely to result in such a disabling contracture, the limb should be so placed that when healing has taken place there will be more extensive scar tissue and less contraction deformity.

I would like to have Dr. Davis say a word concerning his keloid cases. He showed one where there has been a return of some of the keloid after the keloid scar had been removed. I did not get a nice operating fee in one case because I was afraid to remove a keloid lest more keloid would return. It would be interesting to me to know if keloid can be removed and healing can occur without return of the keloid.

DR. G. D. MARSHALL, Kokomo, Ind.: In the matter of the prophylaxis of contractions a very efficient splint is the Littler-Jones splint. That offers more access to the part than anything else. Probably most of you have seen it used. It is applied in such a way that the arm is splinted in an abducted position. That allows the same opportunity for moving the arm and dressing it that we have in the Thomas splint. I do not think it is generally used very much. I saw it used by Dr. Armour at the Southwestern Infirmary in Liverpool and thought it was a very useful appliance.

DR. C. L. STARR, Toronto, Ont., Canada: I would like to ask Dr. Davis how long after radiation he feels safe in operating on these cases or any other case. We have had some bad healing effects in attempting to operate on skin that has been recently radiated.

DR. J. W. SEVER, Boston, Mass.: I would like to ask Dr. Davis if he knows

any reason why the skin about the neck or in the axilla not only in colored but in the white individual is more prone to keloid formation than skin in any other portion of the body. Is it due to the surgical technic employed in closing the skin or is it due to some inherent quality of the skin in that region that seems prone to form keloid? I have had a number of keloids form in and about the shoulder after simple operations. I wondered if it is in the skin or in the circulation.

DR. JOHN STAIGE DAVIS, Baltimore, Md. (closing the discussion): In reply to Dr. Ridlon, I will say that I purposely avoided the consideration of the treatment of burns, as this paper deals only with adhesions following burns.

The treatment of keloids is a difficult matter and as yet there has been found no method which is uniformly successful. Much is claimed for radium in these cases, and I have seen some good results, especially in comparatively small areas of recent origin. X-ray is also advocated but my experience has been that it is not entirely satisfactory when used alone. For several years Dr. Stewart and I have been using the following method:—A preliminary preparation with X-ray for three or four doses; then partial gradual excision by the removal of an elongated ellipse entirely in the keloid area down to healthy tissue beneath. The edges are brought together and sutured, and after healing has taken place the process is repeated, and so on until all the keloid is removed and normal skin is sutured to normal skin. In this way the skin surrounding the keloid is gradually stretched and can finally be sutured without tension.

DR. RIDLON: A subcutaneous closure?

DR. DAVIS: Not necessarily, although the subcutaneous suture may be used with advantage in certain cases.

Further X-ray treatment may be given between excisions and after the final operation. All keloids do not act in the same way and I cannot yet say that this procedure is going to be the method of choice, although so far it seems promising.

In answer to Dr. Starr's question as to the length of time elapsing between X-ray treatment and operation. We wait until all signs of reaction such as redness, swelling and blistering have disappeared and the skin is apparently normal.

In answer to Dr. Sever: I do not think that keloid formation has anything to do with the technic used, provided, of course, that the wound is properly closed and per primam healing is obtained. Dr. Freeman of Denver suggested that a piece of fascia sutured under the line of closure to relieve tension, would prevent the reformation of keloid.

We have not yet discovered the cause of keloid but it may be due to something in the skin itself, or possibly in the blood at that particular time. If we knew the causes of keloid and how to prevent its occurrence, it would save us all a lot of heartburn.

TREATMENT OF FRACTURES FROM AN INDUSTRIAL STANDPOINT.*

BY EDWIN W. RYERSON, M. D., CHICAGO, ILL.

In the treatment of fractures there should be no essential difference between the methods employed in ordinary practice and those used in industrial surgery. The intention in any case should be the production of a solid and satisfactory union with the fullest function in the shortest possible period of time. It is true, however, that in many instances it is difficult or even impossible to determine the exact moment when solid union has occurred, and unless there exists some reason for shortening the period of disability, the average practitioner is apt to delay the active use of the fractured limb until perhaps an unnecessary loss of time has resulted. It is largely due to the influence of the industrial surgeons that attention has been brought to the economic side of the question, although during the War there was considerable activity in military practice along these lines.

Relatively speaking, fractures unite more rapidly in the young than in the old, and yet, in a group of individuals of equal age there may be a wide variation in the time of union of similar fractures. There are several factors influencing the union of fractures, which have not been sufficiently studied. Why, for example, do we see fractures of the tibia in young children, usually boys, which refuse to unite in spite of the fact that the bones are in exact apposition and securely maintained by suitable apparatus? I have seen several such cases, one of them following a simple osteoclasis for bowleg. These fractures remained ununited for many years, although bone-grafting operations were performed in most of them. The humerus is another favorite site of non-union, at all ages. A certain amount of investigation has been carried out along endocrine and other lines, but nothing definite has been established.

Another point which requires study is the relative value of complete and incomplete fixation of the fragments during the process of healing. Many excellent surgeons believe that perfect fixation is highly desirable. Other surgeons, equally well-known, think that more or less movement of

*Read at the meeting of the American Orthopedic Association, held in Rochester, New York, June 7-9, 1923.

broken ends produces quicker and stronger union. It would be an excellent piece of work for some of our younger members to investigate this moot question.

It will be accepted by everyone, I think, that perfect anatomical replacement or reduction is followed by quicker union and more satisfactory function. An overlapping or side-to-side position of the fragments must, I believe, require more deposition of new bone and more rearrangement of structure than a perfect end-to-end position. It is, therefore, of prime importance to obtain the best replacement which is possible. In some cases, such replacement may be obtainable only by incurring undesirable risks, and it may be wise to content one's self with an imperfect reduction rather than to undertake an open operation, or a succession of anesthesias. It is my impression that the younger surgeons are apt to operate on too many cases and the older surgeons on too few. There is doubtless a happy mean, but it cannot be established by any set of rules.

In a few words, then, we must use the best judgment that we have in deciding whether or not to operate upon a questionable case, and, in operating, the simplest method is usually the best. The periosteum and soft tissues should be separated from the bone to the smallest extent possible, since it is from these structures that the bone derives its most important blood-supply. Without a good blood-supply, osteogenesis occurs slowly and slightly. This point is overlooked by many surgeons, who strip and expose the bone very freely, and to an extent usually unnecessary. Nearly all fractures unite much more slowly after any kind of an open operation than when not cut down upon. The reason for this is not entirely clear, but it is probably due in greater part to the diminution of blood-supply on account of the denudation of the bone, and in smaller part to the introduction of foreign material used for internal fixation purposes. The various methods of internal fixation will not be considered in this paper.

The external fixation of fractures is a subject of great importance. It has been my opinion for many years that a circular plaster of Paris splint or cast produces a greater degree of bone atrophy, and therefore probably a slower union, than does an open metallic or wooden splint. This may be due to the exclusion of light and air, or the greater restriction of muscular action, or to the fact that massage and similar therapeutic measures cannot be utilized if a circular cast has been applied. It is probably due to a combination of all these undesirable factors. It seems to me that light

and air and water and massage are at least as beneficial and pleasant and sanitary for a broken leg as they are for your leg or mine, and yet it is true that a great many of my fracture cases have been treated by plaster of Paris casts. Of late years, most of these casts have been split into anterior and posterior halves, or have had large windows cut out over the injured area, but they still leave a good deal to be desired. If all large hospitals were equipped with brace-shops, it would be much easier to abandon the use of plaster of Paris in all cases except those where immediate and very accurate fixation is needed, but it is not likely that this time will come for many years. At present, many of us are dependent upon the commercial brace-makers, whose apparatus costs a great deal more than it should, and cannot be furnished at a moment's notice. The use of standardized, ready-made splints is rapidly gaining ground in our hospitals, partly through the influence of the industrial surgeons and partly because of the large numbers of men who were trained in their use during the war.

I find that a continually increasing proportion of my fracture cases can be treated more successfully and more comfortably by metallic splints than by plaster of Paris and that their period of disability is definitely shortened. Very many fractures need traction, and traction can usually be made more easily and more efficiently in apparatus than in plaster of Paris casts.

The work of the physiotherapeutists has emphasized the need of active and passive movements of the joints at earlier periods than has been the custom of many surgeons, and this is a point of great importance. The function of a hand can be brought to the normal, after a Colles' fracture, three or four weeks earlier if movements and physiotherapy be used than is the case when prolonged fixation is employed. The stiff knee, so often seen after the old routine treatment of a fractured shaft of the femur, can be prevented by the use of the Thomas splint with the hinged knee attachment. Even in fractures of the neck of the femur, manipulations of the knee joint can be carried out by careful attention, although there may be considerable danger in the older cases. Pott's fractures and fractures of the os calcis, however, require long and complete fixation and protection from actual weight-bearing.

In conclusion, the object of this paper is to encourage the wider use of physiotherapeutic methods and also the use of splints and apparatus in suitable cases, rather than the more convenient and less expensive plaster

of Paris circular casts. It is realized that in many cases, especially after open operation, a plaster of Paris dressing affords a simplicity and security which cannot well be substituted. It should be pointed out, however, that in oblique or incompletely reduced fractures of the shaft of the femur, a long plaster of Paris spica is the most unreliable and imperfect method of attempted fixation that can be applied. Inside of it, over-riding and angulation can occur with ease and with very little external evidence, so that it is sometimes appalling to examine the roentgenograms taken a week or two, or a month or two, after the surgeon has completed what seemed to be an excellent reduction.

DISCUSSION ON PAPER OF DR. RYERSON.

Dr. Robert D. Schrock, Omaha: It is my conception that a discussion of the after-care in the treatment of fractures has to do with that period after reduction of the fragments has been made as satisfactorily as possible; that the after-treatment begins at a time when the position and alignment would not, under ordinary circumstances, be disturbed. After-treatment, then, is concerned with the methods of therapy that tend to increase the rapidity of bony union and the regaining of function of the injured parts. Adequate or increased circulation of blood in the injured part is the first requisite.

The type of splinting material and its method of application varies with the individual operator. "Ready-to-wear" splints of the Thomas type are now in more common use than is plaster-of-Paris fixation. In the mind of too many men handling fractures, the application of a Thomas type splint satisfies the requisite. They feel that a Thomas splint should automatically give a good result. Traction and suspension methods, where successful, demand daily personal observation and repeated adjustments by the surgeon in charge or by an adequate assistant thoroughly familiar with the individual fracture under treatment.

There are some hospitals in which the nursing staff grows old in service. Some nurses can be trained to handle mechanical devices; other nurses have no sense of mechanics and it is a waste of time to attempt to teach them. This applies as well to the rotating house-staff, especially in the smaller hospitals.

It has become our habit to use plaster-of-Paris fixation more than the Thomas type splinting. Traction can be readily obtained in plaster splints. We have a feeling that our fractures are a little more secure and that the changes in position required by nursing care are less liable to cause disaster in the reduced fragments. Plaster gives security and comfort if properly applied. The application and removal of plasters is usually turned over to the junior on the house staff. It is regarded as a dirty job and belongs to him. Good technicians in plaster are becoming rarities. This is regrettable.

Plaster gives security, and security is an essential until the fragments are so thoroughly cemented that the union is dependable for careful manipulation The plaster can, with a little work, be so cut that segments can be removed for massage and active muscle motion. It is our habit to have the patients begin active contraction of muscle groups within the plaster during the first ten days. This increases circulation, prevents muscular atrophy, hastens bone formation and furnishes amusing activity for the patient.

There are dangers in early motion in fractures. Motion of the adjoining segments, which does not produce pain, is distinctly beneficial. The range of motion must be restricted to the pre-pain point. Passive motion is rarely limited to

this point, due to the ambition of the surgeon. Passive motion producing pain is contra-indicated within the first month because the opposing muscles are reflexly taught to go into spasm when motion is attempted. In fractures in the shafts of long bones, very early motion in the adjoining segments is contra-indicated. Very early active muscle contraction can be instituted. In intra articular fractures, especially in the elbow, wrist, and ankle, active motion can be beneficially started within five to seven days.

In the repair of fractures there is a need of bone-forming elements. In the adolescent bone, metabolism is at a high tide and new bone formation is rapid. In rickets, cod liver oil, lime salts, and phosphorus have for years been a great aid. The pharmacy furnishes some elements in the after-care of fractures. These we too often forget or disregard.

The after-care of industrial patients must be considered from three angles:

1. From the standpoint of the employee—"How soon can I go back to work?" Too often a second question is aroused by extraneous and nefarious legal advice, "How much will the company pay me for my disability, and can I get enough so I do not have to work any more?"

2. From the standpoint of the employer come the questions—"How rapidly can I get this old employee back to work so as to decrease the cost of turnover?" "How much disability is he going to have? Can he go back to his old job or shall I have to develop him for a new job?"

3. From the standpoint of the insurance companies—"What will be the cost of this accident in surgical fees, hospital bills, and compensation claims?" The employer and insurance companies reason in terms of hard cash. To them, efficient treatment means decreased total costs.

One of the largest insurance companies has recently formed an adequate organization for the supervision of the accident cases. Everybody recognizes this as a distinct advance in the care of industrial accidents, and we may anticipate before many years interesting information as to average periods of disability and average cost and percentages of disability in various types of fractures.

DR. CHARLES A. PARKER, Chicago, Ill.: I wish to express my great appreciation of the very entertaining and very instructive articles that we have had this afternoon. There are just two or three points that strike me a little peculiarly, that is in regard to plaster work. One of the gentlemen discussed it and said it was left to the first or second assistant to do the plaster work. Some time ago in one of our large city hospitals in which I work, I inquired about a cast and was told that the ward man put it on, as it was only a simple cast. I told him emphatically that we do not have simple casts. When we have a plaster cast we have it for a purpose. Not long ago I had two internes come from a larger institution to a smaller institution where I do the work for crippled children and they said, "We wish somebody would teach the 'lost art' plaster-of-Paris work." I am afraid they were pretty nearly right. Good plaster work will do wonders.

There is just one little item I might add to the record in regard to the old question, shall fractures be fixed tightly or shall they be allowed a little movement in order to heal? Our experience runs through fractures that we have made intentionally. I suppose every year we correct from 50 to 75 legs, maybe 100 to 150, and in the last ten years that has mounted up to a great many. I have had only one ununited fracture and it is united now after ten years. They have all been put up in plaster.

DR. JOHN H. BASSIN, Newark, N. J.: I would like to say a word about the industrial aspect of fractures, in which I am especially interested. You will probably recall that in 1919 New Jersey was the first State to establish a rehabilitation commission. In 1921 we made a report of the unsatisfactory end-results of 442 fractures of industrial origin before adjustment by the Workmen's Compensation Court, pointing to the importance and manner of early fixation

and degree of passive joint motion; also the lack of diagnosis relative to patient's constitution regardless of the fracture. In other words, many cases of fracture had been treated over months without checking up co-existing syphilis, tuberculosis, focal infections, the latter especially about the prostate, and in women often a chronic endocervicitis. The Manufacturers Associations and the Compensation Courts view these conditions from a purely industrial-economic angle. There is a general tendency to put industrial surgery on the so-called productive basis. As a matter of fact it cannot be done as precisely as they would like to have it because the purpose of the workmen's compensation statutes in most of the States is compensation rather than rehabilitation. I believe that the younger members of the profession should be taught to look more carefully into fracture cases with focal infection. The practical question is not so much bone union in absolutely perfect alignment, but that of complete restoration of proximal joint function. A half inch or an inch of leg shortening will not disable a man, but loss of joint function is a very serious matter. Therefore physiotherapy also should be given early. I should also advocate passive motion in Pott's fracture at the end of the fifth day. Physiotherapy in industrial surgery is very important, although we are not yet quite ready or willing to put industrial surgery on a so-called productive or purely commercial basis.

Dr. John Ridlon, Chicago, Ill.: As I have listened to this discussion I wonder why it is that I have had no stiff joints following immobilization, and I have wondered why is it that I have had no trouble with my fractures, and I suspect that the answer is this: that when I have a fracture to treat I treat it myself. If it has to have a splint I measure for the splint, fit the splint, and apply it when it is made. No nurse or interne does it for me. If I treat it with a cast I put on that cast and if the cast has to be cut off I cut it off myself. I treat that fracture myself and if I have not time to treat it I let somebody else treat it and the result is his whether good or bad. I think that explains some of these unpleasant things you are talking about and fearing. In treating a fracture it seems to me very simple: that you should put the ends of the fragments together any way you want and keep them there until you get union. I do not trust in God to make traction. I make what traction I want, and it stays there until I take it off. I do not trust in God to get motion, or not get motion. If I have a fracture I am aiming to get a union of that fracture and when I have union I aim to get motion in the neighboring joint, and somehow I always get it. I suppose it is because I treat the fracture myself instead of having somebody else do it.

Dr. Edwin W. Ryerson, Chicago, Ill. (closing the discussion): Dr. Schrock was quite right in criticizing my paper on after-treatment of fractures, but I would point out that the after-treatment of fractures begins after the fracture. The reason I first began thinking about what happens under a plaster cast was this,—not so many years ago in some of the German clinics instead of doing an osteoclasis or osteotomy for bowlegs or knockknees, they put plaster casts on the children's legs and in a few weeks the bones were so soft that they could take them in their hands and bend them straight. That makes you sit up and think a little. Another problem was how well a plaster cast would hold these bow-legs after operation. Dr. Parker believes that a cast holds the leg immobile, but, take a fat, chubby little boy with bow-legs, break the legs and put on casts, and the legs are not as chubby and thick a week after operation. It will surprise you to find how many vacant spaces exist between the child's leg and the cast after it has been on a week.

REVIEW OF THE TREATMENT OF INFANTILE PARALYSIS AFTER THE ACUTE STAGE.*

BY ARTHUR T. LEGG, M. D., F. A. C. S., BOSTON, MASS.

During an experience of six years in charge of the Harvard Infantile Paralysis Commission Clinic, I have had the opportunity of following the course of the disabilities of about 2400 cases under palliative and re-educational treatment and of seeing the results of varied operative procedures in the hands of different men of equal ability. Certain impressions have become convictions, and I shall try to present the conclusions drawn from them. It must be borne in mind that these conclusions are based on the treatment of clinic cases, many of them from scattered country districts where the theoretically ideal conditions of daily muscle-training by an expert and of avoidance of all fatigue are economic impossibilities.

Orthopaedic treatment should be begun as soon as the acute cerebral, or febrile, symptoms have subsided. We all know that it is usual for a child without extensive involvement to be allowed to sit up at this time, with hips and knees flexed, feet hanging, and perhaps a postural curve in the spine. This sitting position is often the cause of the occurrence of one or more deformities which could have been prevented by recumbency and light wire splints. Moreover, the complete rest thus obtained aids in the disappearance of any sensitiveness that may be present.

The sensitive stage is an important one, as its disappearance is the guide for the beginning of active orthopaedic treatment. The severity of the sensitiveness varies greatly, and although it may be entirely lacking in some cases, a moderate amount in the posterior knee muscles is frequently overlooked. A duration of six months is not at all unusual. No active treatment should be carried out while pain is present.

It is certainly true that any active treatment, such as massage and exercise, will prolong the painful period, and it is also true that the beginning of treatment will cause sensitiveness to recur in certain patients who have been free from pain, and that another period of rest will result again

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in its disappearance. A striking example of this was a patient seen two months after the onset, where the mother had been massaging diligently every day. Both ankles were very sensitive. After the massage had been omitted for about a week, the pain was relieved. The massage was again started, and the pain immediately returned. In this case it was necessary to omit the massage for nine months before any real treatment could be started.

The best treatment for the sensitive stage is absolute rest, hot baths, and hot blanket or electric light bakes. Some of the most striking instances of nearly complete recovery after marked involvement have occurred in patients where this routine was faithfully carried out over a sensitive period of many months' duration.

As soon as the sensitiveness is over, active orthopaedic treatment, massage, and re-education or muscle training may be begun. Massage will keep up and improve the circulation of the muscle itself, and muscle-training will increase the strength and function. During this period, weakened muscles should not be allowed to remain in a stretched position, for stretched muscles do not gain in strength. We have obtained a much higher per cent. of recovery in affected deltoids since we have used platform splints to support the weight of the arm and take the strain from the deltoid.

The development of contractures, either from over-balance of power or from habitual position, results in a continuous stretching of the opposing muscles, and should be prevented. This is especially important if weight-bearing is a factor in producing the stretch, as is the case with weakened foot muscles. Given a case with weakened tibialis anticus, weight-bearing without support will not only put this muscle on the stretch, but will allow the formation of bony deformity by continued weight-bearing in a valgus position.

While we do not like to encumber a patient with braces, especially when the involvement is slight, I believe that no patient should be allowed to sit up, or to stand, without support, if in so doing a weakened muscle is put on the stretch or a joint must assume an abnormal position to maintain balance. We cannot expect the same prescription of restricted activity and a built-up heel which may be suitable for an office case of moderate involvement to prevent deformity in a clinic case. With the awkward hip-limps, it may be necessary to keep the patient off his feet entirely until the

muscles regain sufficient power to render unnecessary the habit of throwing the body to obtain better balance or greater speed in locomotion.

Partially paralyzed muscles continue to show gain under supervised muscle-training for an indefinite period, the greatest gain being made during the first two years. Later on the rate is much slower. The muscles, however, gain only where there is no deformity. From the time that deformity begins, the weaker muscle or muscle group becomes gradually weaker.

Over-use is another harmful factor, and its ill effects become evident as the parents gradually become lax in following treatment and allow unrestricted activity.

It is sometimes asked whether it does any good to continue muscle training on a chronic case. We have found that very weak muscles lose power when regular treatment is discontinued. Stronger muscles lose somewhat, or may remain at a standstill without undergoing actual loss. As normal muscles go on gaining, they are proportionately weaker as time goes on. This frequently results in the development of contractures and deformities, oftentimes leading to operations which would not have been needed if regular care had been continued.

A late deformity that is much more common than is supposed is cavus, occurring in feet without apparent weakness, as well as in feet with considerable involvement. Between 35 and 40 per cent. of feet, either considered normal at the initial examination, or which appear to have become normal after slight involvement, develop the cavus deformity. The rapid increase of this deformity, accompanied by the gradual weakening of the extensor longus digitorum and the peroneal muscles, and the development of hammer-toes, varus, and discomfort, is apparently not recognized.

As to the question of when to start operative procedures for cases of poliomyelitis, operations for the relief of contractures should be done as soon as a reasonable attempt at stretching has failed. In private practice, where a case can be watched carefully, these operations should seldom be necessary. In the case of a shortened Achilles tendon, the choice of subcutaneous tenotomy or tendon lengthening seems to vary with different operators. I believe a subcutaneous tenotomy should never be done. I have seen many cases with contracted tendons of normal power develop a marked calcaneus with gastrocnemius weakness following the subcutaneous oper-

ation. If this contraction cannot be relieved by a stretching splint or plaster, it should be done by an open tendon lengthening.

Tendon transplantations to re-establish the balance around a joint may be begun at the end of the first year. By that time we know fairly accurately what the muscles involved are going to do, and can say definitely what muscles will never be functionally serviceable, if, in spite of good supervision, they have remained in a condition of nearly complete paralysis for that length of time. Furthermore, bony deformity requiring operative corrections should not have become established as early as this.

However, if bony deformities of the foot have developed, they must be corrected, and the foot made as mechanically perfect as possible for weight-bearing before any transplantation is done. A foot which has regained almost perfect function and power after a successful transplantation is still a weak foot if weight-bearing produces a deformity. Furthermore, if torsion of the femur or tibia, or knock-knees, have developed, these should be corrected to obtain a good line of weight-bearing, for no leg will be functionally serviceable, whatever its muscle balance, if its mechanics are wrong.

Another point to be considered in determining the operations to be used is the fact that transplantations are bound to fail unless good postoperative treatment is carried out. The transplanted muscle is temporarily weakened by the operation, and must have careful massage and exercise to enable it to regain its strength. It must also be given careful re-education to enable it to take up its new function, for in many cases the mere mechanical change in its line of pull will not cause it to produce the new action. When postoperative treatment is first started, action in some transplants can be produced only by attempting the original function. If these cases are not carefully re-educated, they will not acquire the new function, and the success of the operation is lost. It is a very delicate matter to obtain good function in an uncertain transplant, and even careful instruction to intelligent parents does not produce the results which can be obtained by skilled workers.

I believe that light massage and baking should be started as soon as the stitches are out and the wound healed, and, at the end of three weeks, a very little exercise for the transplanted muscle. If the tendon has been anchored properly, its new attachment should by this time be firm, and prolonged disuse will cause atrophy and inability to gain power. At the

end of eight weeks there is no reason, provided the foot is held by a brace in an over-corrected position and the muscle-training continued, why the patient should not begin to walk. The cases must be watched most carefully, however, for a number of months, to guard against tiring and to make sure that the brace is holding the foot in the over-corrected position. If this after-care is not obtainable, stabilization is indicated.

Where the tibialis anticus alone is weakened, the extensor hallucis inserted on the inner side of the first metatarsal is generally sufficient to re-establish balance.

If the anticus is completely paralyzed, the hallucis tendon will not be sufficient, and a peroneal should be moved to the inner side of the foot, but not as far over as the tibialis anticus insertion. If this is done, the foot will be over-balanced and a varus deformity will follow. Insertion into the second metatarsal will generally not over-balance the foot.

If abduction of the os calcis is produced by weight-bearing, a sub-astragaloid wedge with its base to the inner side of the foot should be removed, in order to adduct the os calcis.

The loss of power on the stronger side of the foot caused by the removal of the transplant must always be considered before deciding upon an operation.

In the event of paralysis or weakness of both the tibialis anticus and posticus, a more marked loss of balance occurs. In a case of this type, the transplantation of the peroneus longus through the tibialis anticus sheath, as described by Meyer, is the ideal operation. Here, again, abduction of the os calcis should be corrected, and if valgus of the fore-foot is present, stabilization of the astragalo-scaphoid joint as performed by Hoke should perhaps be done.

In the case of paralysis or weakness of the peroneal group, a most satisfactory result can be obtained by transplanting the tibialis anticus to the fourth or fifth metatarsal, depending on the relative strength of the peroneal group. Here, again, if the bony architecture of the foot is at fault, it should be corrected.

With much involvement of the gastrocnemius, a bony deformity of the foot is always present. We always have a calcaneus and frequently a cavus.

Where the gastrocnemius alone is involved, transplantation of the tibialis posticus and peroneus longus to either side of the Achilles tendon

or through the os calcis will give a very satisfactory result, provided the bony calcaneus and cavus deformities are corrected.

The power in plantar flexion after the transplantation of these muscles I have never seen return to normal, but they give an excellent functional result. Should the tibialis posticus as well as the gastrocnemius be involved, both peroneals transplanted to the os calcis should be done. Often in this type the extensor hallucis may be transplanted to the first metatarsal to advantage when there is valgus of the fore-foot.

Given a case with complete paralysis of two or more groups of muscles, re-establishment of balance is impossible, and our main object should be to give the patient a stable foot to stand on.

It comes down to the question of astragalectomy, or a stabilizing operation without astragalectomy. An astragalectomy will give a stable foot and a foot in good position for weight-bearing, if performed and put up accurately. Unfortunately, many are not so performed and we in time see a marked varus or calcaneus, or both, develop. I believe these are wholly due to faults in technique.

It must be said, however, that after doing this operation, we have shortened an already short leg about three-quarters of an inch. A stabilizing operation will not shorten the leg, and if thoroughly done will, I believe, obtain as stable and serviceable a foot as an astragalectomy. This stabilizing operation as performed by Hoke certainly gives a very satisfactory foot. We have only to see Hoke's work to realize the accurate knowledge he has of the architecture of the foot and its application in his operations.

We are too apt to criticize or discard an operation which has been carefully worked out, when we have failed to learn the exact technique and its indications as presented by its author.

There is much discussion as to the age at which transplantations and the necessary bone operations should be done. I believe that before the age of four or five, a child is not sufficiently capable mentally to concentrate and aid in the re-education after transplantation, but at this age there is no reason why transplantation should not be performed. The necessary bone operations will in no way, I believe, retard the development of the foot if done at the same age.

The problem of establishing balance about the hip is a difficult one. The limp from a gluteus maximus or medius, or both, is distressing, and

no operation I know of will relieve a hip extensor limp. I have been getting satisfactory results in the tensor fasciae femoris transplantation for gluteus medius weakness. It should be remembered that this operation will not relieve the limp in the presence of lateral abdominal weakness.

Transplantations at the shoulder-joint have been generally unsatisfactory. Although trapezius and pectoralis major transplantations have been done many times, I have yet to see a satisfactory result where there was complete involvement of the deltoid. Very gratifying results are now being obtained by transplantation at the hand, especially to increase thumb function.

In conclusion, the points which I wish to emphasize are that the evil results of

over-fatigue,
general exercise treatment without regard for muscle balance,
weight-bearing without mechanical support in positions which favor deformity,
tendon transplants without regard for the bony mechanics of a foot,

are not matters of theory, but are facts which have been proven to me by the personal examination of these twenty-four hundred cases, not only once, but many times.

DISCUSSION ON PAPER OF DR. LEGG.

DR. FREDERICK KIDNER, Detroit, Mich.: Dr. Legg has given us a most sane and thorough review of the very best types of treatment of infantile paralysis, based, however, on work done in the apparently civilized confines of New England. There are certain things about it that perhaps do not apply so well to our wilder state of Michigan; in other words, we cannot carry out in Michigan the details to the extent to which Dr. Legg has given us the guide. We have much more difficulty in keeping our patients for a great length of time. We have more often to give them a lick and a promise and see them again three years later. We have for that reason much more deformity than Dr. Legg believes is common in New England. For instance, I rarely see a case of infantile paralysis a year or two or three years after the occurrence of the attack which has not a greater or less degree of deformity. Our task is that of correcting the deformity first and then getting fool-proof results. I have found in my work in Michigan that tendon transplantation, except in very selected cases, is not satisfactory because it is rarely that we can get the proper cooperation and proper after-care. We are forced to do the bone operations more frequently than they do at the Children's Hospital or at the Clinic in Boston. We have got to do things that the parents can care for at home. When you think that most of our cases come from the Northern Peninsula, 400 miles away, stay three months and then go home, usually to remain there, you can imagine how good this work of Dr. Legg sounds. I think tendon transplantation is not satisfactory unless one has the child under absolute control.

DR. EDWIN W. RYERSON, Chicago, Ill.: Dr. Legg in his very admirable paper has laid a good deal of emphasis upon tendon transplantation. For a great many years I have been doing a large number of tendon transplantations, and on looking them over recently I was very much disappointed in the results. Now, for years I have appeared before this Society in defense of tendon transplantation and in the advocacy of different methods of tendon transplantation, and it was only a year or two ago that I found what was to me a satisfactory explanation of why the average tendon transplantation does not produce the desired results.

In the first place if there is any tendency to lateral deformity in the foot it cannot be controlled by any of the ordinary tendon transplantations. It took me a long time to find that out but I am just as certain of it as that I am now speaking about it. The reason those tendon transplantations did not succeed is because we are transplanting across a joint or a series of joints to a point distal to these joints; and the proximal joints, the subastragaloid and mediotarsal, are not controlled by tendon transplantation. For instance, if we insert a tendon distal to the subastragaloid and mediotarsal we are asking a little guy rope to control the movements in the joints proximal to this insertion. I am firmly convinced at the present time that if we are to do tendon transplantation for the control of a lateral deformity—understand, I mean varus and valgus, inversion and eversion—we must stabilize the intermediate joints, the subastragaloid and mediotarsal. Of the joints in the foot that may cause lateral deformity, the more of these joints that we stabilize the better our results are going to be. I can urge you very strongly not to perform tendon transplantation, except in rare instances, until these children have arrived at an age where we can safely and securely cause an ankylosis of these intermediate joints. Our aim should be to make a foot that can be walked upon. A child with infantile paralysis is never going to be a toe dancer and is never going to do any fancy performances with the feet but she is going to walk; and in walking, extension and flexion are the two most important acts. I think we should subordinate our tendon transplantation to perfecting strong extension and flexion and we should prevent deformity by making an arthrodesis of these intermediate joints.

DR. J. T. RUGH, Philadelphia, Pa.: I think this paper is an extremely timely one as showing what can be accomplished by a carefully controlled center such as they have in Boston. I want to stress what Dr. Kidner has said as to the findings of those of us who are working where the work has not been centralized and where we get cases in which the deformities are still present, and where there is no possibility of directing the case from the very beginning. These patients have been out from under supervision for one, two, or five years and we are dealing with the end-results rather than with conditions in the course of their progress. I think that must be stressed, because it is the point with which the vast majority of orthopaedic surgeons have to deal, and that is the angle from which they must face the problem.

I confess that our children in Philadelphia and from what Dr. Kidner says those also in Detroit are not so far advanced mentally as in Boston, so that a tendon transplantation can not be performed at four or five years and sufficient coöperation secured to have the child take care of its muscle afterward. I believe also that success lies in the early control of cases, the careful following out of instructions and the directing of the child's attention to the condition from the onset of the attack through the years. We do not get it. If I can get mental coöperation from my patients at the age of ten years, I feel I am getting excellent results in my cases. Therefore, I do not do my tendon transplantations before nine or ten years of age.

I heartily endorse what Dr. Ryerson has said in regard to stabilizing the bony structures in addition to the tendon work.

DR. M. H. ROGERS, Boston, Mass.: It seems to me in regard to the tendon transplantation, as Dr. Legg has presented it, that his statements show the great necessity of doing tendon trassplantation to prevent deformity where there is an unbalanced foot. If we cannot control these cases of four or five years, and there is an anterior tibial paralysis and a strong valgus, we are bound to get deformity, and as I grasp Dr. Legg's paper, his transplantation was for the purpose of preventing that deformity and not to correct the lateral deformity. I think it is taking away the vicious pull as well as putting the pull in the proper location.

DR. COMPTON RIELY, Baltimore, Maryland: Dr. Legg has brought up a question that I think is of great importance but not generally recognized: that is, the danger of using electricity and massage early in the treatment of these cases. I think we obtain better results without these measures. This treatment seems not only to prevent development of the muscles but causes more soreness. I believe placing the limb in a relaxed position with plaster in the early stages, and not only in the early stages but as soon as you get the patient, even though he is ten or twelve years old, will allow him to obtain more power in the paralyzed, or apparently paralyzed, muscles than any other means that I have used. I believe also that such operations as for the production of an ankylosis of the joints in the early stages are almost useless; in fact, tendon transplantations seem to fail because of the softness of the bones.

DR. WALTER TRUSLOW, Brooklyn, N. Y.: It will not do for us to say that we cannot control these cases, that they do not come to us and that we cannot follow them. We hope we will never have another such epidemic as that of 1916; but we do not know. I think the great value of this paper is in telling us just how to meet this condition again and if in Boston (and, as I am glad to say, in Brooklyn) we are able to carry through much of what is advised, we have learned a good lesson. Personally I think the lesson from the first half of this paper is the advantage of protection as compared with the disadvantage of over-stimulation. If we will get that lesson we will get the most important feature of this paper.

DR. A. G. COOK, Hartford, Conn.: I do not want to take up too much time because I am an old-timer. If a foot is paralyzed it will drop like that (indicating). You can do an arthrodesis, a bridge operation or a Hoke operation or anything you like and shortening the arch of the foot, but the foot still drops. If, on the other hand, you do either a Davis operation or an astragalectomy and push the tibia or fibula forward or the foot backward, the foot does not drop. Now we know that that makes a very good foot if done properly. No matter what you do, if you do not displace the foot backward it will drop. Dr. Campbell has a new method for this purpose. He has put in a wedge and the foot does not drop. The thing to do is to contrast Dr. Campbell's operation with the Davis operation of displacing the foot backward or astragalectomy and determine which operation is best. I should imagine that in some cases where there is not much deformity of the foot that we might split the astragalus.

DR. CHARLTON WALLACE, New York City: Dr. Legg's paper was thoroughly enjoyed by me and I should like to comment upon several points. One would especially like to commend Dr. Legg upon advocating shortening the time between the onset and operation. I agree with him that the interval between the onset and the time of operation has been too long and that valuable time has been lost for these children by waiting a number of years. Personally it is my opinion that waiting two years for the return of function is long enough.

Tendon transplantation has been more or less disappointing, except for two groups of tendons. Transplantation of the biceps for quadriceps paralysis gives excellent results, and transplantation of the tibialis anticus for a varus paralysis, where the other tendons in the affected foot are active, has also been satisfactory.

So far as securing a functionating foot for running, walking, and standing, where there are two or more groups of muscles paralyzed, I know of no operation as efficacious as astragalectomy with backward displacement of the foot. This operation after Whitman has been performed by me for many years and there are patients upon whom it has been done on both feet, who can run and play baseball, when otherwise they might be wearing braces or have flail feet. The unquestionable value of the astragalectomy operation is firmly established and is recommended as the best procedure in the latter mentioned types of paralyses.

DR. ARTHUR T. LEGG, Boston, Mass. (closing the discussion): I have been very fortunate, of course, in being able to see most of the cases at the onset or shortly after the onset. The point in this paper I wish most to bring out is the fact that a great deal of bony deformity can be prevented if we have an opportunity to watch the cases from the beginning, and oftentimes in these cases we may prevent any bony deformity from occurring and we can do a transplantation which will re-establish balance in the limb and not necessitate operation.

News Notes

On November 23rd, in Chicago, a portrait painted by Carl Bohen, of Dr. John Ridlon, the Father of Orthopaedic Surgery was unveiled and formally presented to Dr. and Mrs. Ridlon at the Surf Hotel, where they are now living. The unveiling followed a delightful dinner celebrating his seventy-first birthday, at which were gathered Dr. Ridlon's children and grand-children together with the donors of the portrait, many of whom had been students of Dr. Ridlon and are now prominent orthopaedic surgeons in many cities. The principal speakers were Dr. Albert H. Freiberg of Cincinnati, Ohio; Dr. John Lincoln Porter, and Dr. Henry Bascom Thomas of Chicago. Dr. H. Winnett Orr of Lincoln, Neb., acted as Toast-Master. Informal tributes were paid Dr. Ridlon by Mr. Carl Bohen, Chicago; Dr. M. S. Henderson, Rochester; Dr. Emil Geist, Minneapolis; Dr. Arthur Steindler, Iowa City; Dr. Philip Hoffman, St. Louis; Dr. E. W. Ryerson, Chicago; Dr. F. J. Gaenslen, Milwaukee; Dr. Willis C. Campbell, Memphis; Dr. C. A. Parker, Chicago; Dr. Philip Lewin, Chicago; Dr. Walter Stern, Cleveland; Dr. H. B. Thomas, Chicago; Dr. H. W. Meyerding, Rochester; Dr. J. B. Griffith, Kansas City, Mo.; Dr. John L. Porter, Chicago; Dr. Chas. L. Jacobs, Chicago; Dr. H. Winnett Orr, Lincoln, Neb.; Dr. W. E. Blodgett, Detroit; Dr. E. J. Berkheiser, Chicago; Dr. J. P. Lord, Omaha, Neb.; Dr. Albert H. Freiberg, Cincinnati; Dr. C. F. Eikenbary, Spokane; Dr. J. E. Thomson, Lincoln, Neb.; Dr. Archer O'Reilly, St. Louis; Dr. W. H. Cole, St. Louis; Dr. G. D. Marshall, Kokomo, Ind.; Mrs. Joseph L. Hempstead, Chicago; J. R. Ridlon, New York City; Mrs. Captain Dirk Van Ingen, Fort Sheridan; Noel Ridlon, Chicago; Mrs. Jean Piccard, Lausanne, Switzerland; Hugh Owen Thomas Ridlon, Detroit. A message was cabled from Liverpool by Sir Robert Jones, the leading orthopaedic surgeon of Europe, and a great many letters and telegrams were received from physicians in this country who were unable to be present.

The Section in Orthopedic Surgery of the New York Academy of Medicine met on Friday evening, November 16th, 1923. Dr. R. E. Humphries, the chairman, and Dr. Sigmund Epstein, the secretary, had prepared the following programme:

Presentation of Cases, (from Post-Graduate Hospital). (a) Multiple foreign bodies in knee. (b) Results of trauma from reduction of congenital dislocation of the hip, (two cases), Elmer P. Weigel. (c) Unusual abduction deformity of the hip subsequent to poliomyelitis, Leo Mayer. (d) Double clubfoot; operation at the age of seven. (e) Pseudo-hypertrophic muscular paralysis, Charles Ogilvy. (f) Cases of extra-articular arthrodesis for tuberculosis of the hip, Fred H. Albee.

Paper of the evening, Arthroplasties of the Knee. Moving pictures of the operation and results. W. R. MacAusland, of Boston (by invitation).

CHICAGO ORTHOPEDIC CLUB

The next regular meeting of the Chicago Orthopedic Club will be on Friday, January 11, 1924, at 8 P. M., Room 1308, 30 North Michigan Avenue, corner of Washington Street. A cordial invitation is extended to all those who are interested. JANUARY meeting will be a Clinical Meeting.

JOHN RIDLON,
President.

H. B. THOMAS.
Secretary and Treasurer.

The British Orthopaedic Association held its annual meeting in Birmingham, October 19th and 20th, 1923, under the presidency of Sir Robert Jones, K.B.E., C.B.

The following papers were presented at the two morning meetings:

1. Observations on Sarcomata of Bone. Sir Gilbert Barling, Bart.
2. Claw Foot. Mr. G. Percival Mills.
3. Claw Foot. Mr. F. Wilson Stuart.
4. Note on a Possible Sequela after Removal of the Internal Semilunar Cartilage. Mr. Naughton Dunn.
5. Case of Snapping Shoulder. Mr. W. Rowley Bristow.
6. A Case Illustrating the Life History of a Bone Graft Inserted After Excision of Bone Tumour. Mr. A. B. Mitchell.
7. The Treatment of Spiral Fracture. Mr. A. B. Mitchell.
8. The Operative Treatment of Bone Cysts. Mr. H. Platt.

A Clinical Meeting with cases was held at the Highbury Hospital, Moseley, on the afternoon of October 19th, with demonstrations by Mr. F. Wilson Stuart, Mr. G. Percival Mills, and Mr. Naughton Dunn.

On the afternoon of the 20th the members of the Association observed the operative work at the Woodlands Hospital for Cripples, Northfield.

The next meeting of the American Orthopedic Association will be held in Baltimore on May 15, 16, and 17, 1924.

Dr. Nathaniel Allison of St. Louis has been appointed Chief of the Orthopaedic Service at the Massachusetts General Hospital, Boston.

Dr. Harold D. Corbusier announces the opening of his private clinic for orthopaedic surgery at 614 Park Avenue, Plainfield, N. J.

Dr. Solomon D. David announces the opening of his orthopaedic clinic at 704 Lamar Avenue, Houston, Texas.

Dr. James K. Young, of Philadelphia, who has been a greatly esteemed member of the American Orthopedic Association since 1890, died on August 28, 1923.

Dr. Murk Jansen, of Leiden, Holland, will be glad to send to those who desire it, a reprint of his paper on Coxa Plana, with better illustrations than appear in the American reprints.

A meeting of the Section in Orthopedic Surgery of the New York Academy of Medicine was held on Friday evening, Dec. 21, 1923.

The programme was as follows:

PRESENTATION of PATIENTS and REPORTS of CASES:

a) 1. Extreme spinal curvature following infantile paralysis.
2. Supernumerary rib.
3. Fracture of cervical vertebrae: complete recovery.
4. Paralytic disabilities: result of tendon transplantation and suspension. (3 cases). Carl R. Keppler

b) Arsenical neuritis simulating poliomyelitis. Edgar D. Oppenheimer

c) Cases showing the results of the loop operation for paralytic equinovalgus. Joseph B. L'Episcopo (by invitation)

d) Congenital absence of pectoralis major (thoracic portion) and of mammary gland, of one side. Jaques C. Rushmore

e) A clinical study of metatarsus primus varus. Walter Truslow

DISCUSSION

Correspondence

SOME LIGHT ON THE HISTORY OF THE SUSPENSION AND TRACTION FRAME ERRONEOUSLY CALLED THE BALKAN FRAME, BLAKE FRAME, etc.

Editor, The Journal of Bone and Joint Surgery.

That the error is common is shown by the fact that the mistake is perpetuated in almost all the recent text-books on fractures and is almost universal in the current periodical literature. It is not surprising then that this error should crop up in the Journal of Bone and Joint Surgery.

Under the title of "The Evolution of Fracture Treatment or What Have Been the Real Changes," by Stewart L. McCurdy, appearing in the Journal of Bone and Joint Surgery, Vol. V, No. 3, July, 1923, pp. 425-436, on page 435 this statement appears:

"The following extract taken from an article written by Joseph A. Blake clearly shows that the so-called Balkan frame was designed by him:"

"On assuming charge at Hospital B, American Ambulance, Juilly, Seine et Marne, in February, 1915, we were immediately confronted with the practical difficulties of dressing complicated compound fractures of the extremities. From the standpoint of the surgeon these dressings were time-consuming, difficult, and unsatisfactory; to the patient they were long-drawn-out ordeals of pain. With the limited personnel at our disposal it was obvious that we must evolve a more satisfactory method of handling these cases. At this time we were receiving our wounded by ambulance direct from the French field hospitals."

"We believe that the so-called Balkan frame should be called the Blake frame in justice to Dr. Blake's work and for the reason that it is difficult, so far as I have been concerned, to trace the origin of the word 'Balkan'."

This article credited to Blake by McCurdy is an extract from a paper written by me, "The Portable Suspension Frame Employed In The Treatment of the Wounded During the European War" (Erroneously called the Balkan Frame) by H. H. M. Lyle, Anns. Surg. Vol 71, 1920, p. 760-772. For convenience of comparison I reproduce it here—

"On assuming charge at Hospital B, American Ambulance, Juilly, Seine et Marne, in February, 1915, we were immediately confronted with the practical difficulties of dressing complicated compound fractures of the extremities. From the standpoint of the surgeon these dressings were time-consuming, difficult, and unsatisfactory; to the patient they were long-drawn-out ordeals of pain. With the limited personnel at our disposal it was obvious that we must evolve a more satisfactory method of handling these cases. At this time we were receiving our wounded by ambulance directly from the French field hospitals."

These two extracts are identical, word for word, and I feel sure that a mistake or a printer's error must have occurred in transcribing it. The more so as Blake has always freely given me credit for the authorship of the frame.

This can be readily verified by consulting Blake in Keene's Surg. Vol VII, Chap. XVII, p. 460, under the subtitle of Suspension Frame. "This frame was first used in the Hospital founded by Mrs. Harry Payne Whitney at Juilly in the service of Dr. H. H. M. Lyle, early in 1915, and was introduced from there to the American Ambulance Hospital by Blake."

Dr. Alexis Carrel, writing during the early years of the war in speaking of the treatment of compound fractures by the author's suspension and traction method says, "If you should return to my Hospital you would see that all our wounded with compound fractures are treated in your suspension and traction frame. We have gathered at our Hospital in Compiegne a great number of compound fractures of the femur and all kinds of fractures and we congratulate ourselves in having been your pupils. The results which we have obtained by the help of the frame you taught us to use are excellent. Beside greatly increasing the comfort of the wounded your methods have facilitated the irrigation of the wounds. We felicitate ourselves that your stay has allowed us to apply the results of your experience for the good of our wounded . . . . . I feel that the best methods of treating infected fractures are yours."

A. Carrel.

(Translation of a Personal Communication).

This letter, I think, clearly demonstrates Carrel's stand on the question of the authorship.

Dr. McCurdy says that it is difficult, so far as he is concerned, to trace the origin of the word 'Balkan.' It is indeed difficult to do this from the literature, but I think it is possible to clear the muddle by reciting some of the circumstances which lead to the common mistake of referring to the frame as the 'Balkan frame,' 'Blake frame,' etc.

The Balkan method of treating fractures was developed during the Balkan war. It consisted in placing the broken limb in a blanket which was suspended from a pole. How the Author's suspension and traction frame, which bears scant resemblance to the crude Balkan method, came to be erroneously called the Balkan frame, Blake's frame, etc., is readily understood by those who knew the inside history of the early days of American Ambulance in Paris. There was naturally a good natured rivalry between the different services in the American Ambulance, this professional rivalry was intensified by the volunteer helpers of the surgical service who were very prone to take sides and, at times, under the stress of circumstances, became slightly over enthusiastic. There were two camps, the followers of Dr. Blake and those of the rival service. The author having found his frame very useful and being an admirer of Dr. Blake naturally gave him a frame for his own use. Blake readily recognized its possibilities and adopted it as the standard for his wards in the American Ambulance. The frame, the authorship not being generally known, soon came to be called the Blake frame by the volunteer aids attached to his service. The aids of the rival service naturally never spoke of it by its original name or by the name of Blake but insisted on miscalling it a Balkan frame. In this way the original name soon disappeared in the smoke of the rivalry. Our Hospital was too far from Paris and we were all too busy to bother about such matters. It is hoped that this trival historical side-light may help to clear up the confusion that has grown up about the authorship of this frame.

The author's reward consists not in the name but in the satisfaction that the frame played a part in simplifying the application of the cardinal principles of suspension and traction; facilitated the application of the Carrel

treatment; materially lightened the burden of the nursing problem and was a decided factor in promoting the comfort and well-being of the Allied wounded. Its practical value was shown by its use through the French, Belgian, and American Armies. It was also used by many British units.

Naturally the author feels that the erroneous title of 'Balkan frame,' 'Blake frame,' etc. should be corrected and it is for this reason that I am forwarding this communication to you.

Yours sincerely,

H. H. M. Lyle.

Late Colonel M. C., Consulting Surgeon and Director of Ambulances and Evacuation of the Wounded for the First Army, A. E. F.

A CORRECTION

Editor of Journal of Bone and Joint Surgery:

In a recent article published by me in your Journal in the October issue of 1923 on Obstetric Birth Paralysis I made the following statement: "About exercises: Those advocated by J. J. Thomas of Boston seem to answer the purpose well." etc.

I have recently learned from Miss M. E. Trainor that it was Miss Jennie N. Colby who first instituted these exercises. In justice to Miss Colby I wish to make this correction in your Journal.

Very truly yours,

Samuel W. Boorstein.

Current Orthopaedic Literature

FRACTURES AND DISLOCATIONS

FRACTURES OF THE HIP JOINT, C. C. Chatterton, M. D. *Minnesota Medicine*, June, 1923.

The author advocates the Whitman treatment of fractures of the hip, as it allows satisfactory reduction, locks the fractured ends and permits the patient to be moved about and cared for without danger of displacement of the fracture. He cites the following as the cause of poor results:

1. The true diagnosis has not been made; and if made, only meager treatment instituted.
2. The time element is not sufficiently considered.
3. Complications demand frequent change of position in the patient.
4. Poor results obtain even with good treatment because of poor physical condition of the patient.
5. There may be no treatment instituted.
6. Synovia or tissue may be present between the fragments of bone.—*Henry W. Meyerding, M. D., Rochester, Minn.*

FRACTURES OF THE FOREARM, W. H. Cole, M. D., *Minnesota Medicine*, June, 1923.

The author limits his discussion of the subject to fractures of the shaft of the ulna and radius, either alone or in combination, and the head and neck of the radius. He advocates the conservative treatment in fractures and resorts to operation only when all other methods have failed. Splints are discussed and the Jones metal gutter splint is preferred with a right angular splint of the same material for fixation of the elbow. Traction treatment by means of glue he believes mainly of use in compound fractures which require dressings. The indications for the use of the Steinmann pin, he believes, are extremely rare. Where operation is performed, absorbable material, such as kangaroo tendon or chromic catgut, is preferred and, where this is not feasible, bone pegs and small beef-bone plates are used. The after-treatment is the same as in both operative and non-operative patients, and stress is laid upon the advisability of frequent examination to determine adequate circulation in the prevention of ischemic paralysis. Splints are usually removed the third week and physiotherapy carried on, the palmar splint being used for ten or fourteen days and removed daily for massaging, et cetera.

The author recognizes the danger of mal-union and dislocation of the head of the radius and believes that frequent resection is necessary and advisable, inasmuch as excellent results are obtained without interference of function.

In fractures of the shaft of the ulna, open operation is seldom necessary. He discusses the fractures of the radius and calls attention to the fracture above and below the insertion of the pronator quadratus and the necessity of recognizing the displacement associated therewith.

In fractures of both bones of the forearm he recognizes the necessity of end-to-end apposition, although anatomic reposition is unnecessary and good functional results are obtained when the bones are engaged but not accurately placed, the principal danger being cross-union and interference with pronation and supination by too close approximation of the fragments. His conclusions are:

1. Conservative treatment must always be used if possible in the treatment of forearm fractures.

2. Circular plaster-of-Paris dressings should never be used as a routine procedure in such fractures.

3. The use of splints of the coaptation type with a right angular splint for the elbow is the conservative treatment of choice.

4. Operative treatment must use the simplest fixative method possible to obtain results, the use of metal plates or wire being absolutely contra-indicated.

5. Early massage and physiotherapy will hasten recovery of function and accelerate bony union.—*Henry W. Meyerding, M. D., Rochester, Minn.*

TREATMENT OF FRESH FRACTURES OF THE SHAFT OF THE FEMUR, R. Earl, M. D., *Minnesota Medicine*, June, 1923.

The author recognizes the difficulty in standardization of treatment of fresh fractures of the femur and believes the Thomas splint is the nearest standard treatment at the present time.

Earl believes the Balkan frame combined with the use of the Thomas splint gives the best results in the upper third, while below this point he advocates the walking caliper or Thomas splint as an ideal ambulatory treatment. He believes operative interference is seldom necessary. Traction, ten to fifty pounds, is used with adhesive carried well up the thigh and no harmful results have been noted, such as stiffness of the knee, et cetera. Anesthesia is used in applying the initial traction, at which time the muscles are overstretched. In children extension is maintained for four weeks, and in adults from four to six weeks, or until false motion ceases, when a cast is applied for a month. He then applies a caliper walking splint for a sufficient time to insure firm union—usually about six months from the time of injury. Compound fractures are treated with tincture of iodine; soiled tissue is excised and iodine again applied, and, if the fracture is treated within 48 hours from the time of accident, the wound is closed. If not, drainage is inserted and antitetanic serum is routine.

Earl discusses the methods of internal fixation. Kangaroo tendon is preferred and non-absorbable material is avoided. When skeletal traction is

used, he believes the caliper should be given preference over the Steinmann pin.

Bryant's traction is preferred, with both legs suspended, in children.

In infants he folds the thigh against the abdomen so that the foot is in the supra-clavicular space, and secures it there with a broad bandage, care being taken to wash and powder the parts daily to avoid chafing.—*Henry W. Meyerding, M. D., Rochester, Minn.*

NON-UNION IN FRACTURES: THE MASSIVE BONE GRAFT. Melvin S. Henderson, M. D., *Journal A. M. A.*, Aug. 11, 1923.

Dr. Henderson has presented a very carefully arranged list of 221 cases of non-union in which age, sex, location, duration, and result from operation are systematically considered.

He advocates the use of the massive autogenous graft held in place by bone-screws. The paper is brief, practical, and to the point. His conclusions follow:

CONCLUSIONS.

1. Non-union is a fixed state in which the bone has ceased to attempt to repair, and is to be differentiated from delayed union.

2. In the series of 221 cases, the non-union was in the lower extremity in 133, and in the upper, in eighty-eight. The femur was involved in seventy cases, forty in the neck, and thirty in the shaft; the tibia in fifty-four; the forearm in forty-six; the radius alone in twenty, the radius and ulna together in eighteen, and the ulna alone in eight; the humerus in forty-one; the patella in nine; and the clavicle in one. The most common site for non-union in the shaft of the femur was in the middle third; in the tibia, the lower third; in the humerus it was about evenly divided between the middle and lower third; in the radius and ulna combined, the site was common in the middle third. In the radius alone it was most common in the lower third, and in the ulna alone, in the middle third.

3. The bones named in the order in which the best results were obtained are the patella, the radius, the ulna, the tibia, the humerus, the shaft of the femur, and the neck of the femur.

4. The massive autogenous graft is preferred, and firm internal fixation of the graft to fragments is also essential.

5. The fact that occasionally success follows the use of metal plates, bone screws, beef-bone plates, and so forth, does not establish the fact that they are to be preferred to the bone graft. In a large series of cases there is ample proof of their inadequacy.

6. Adequate external fixation must also be provided.—*H. A. Pingree, M. D., Portland, Me.*

NON-OPERATIVE TREATMENT OF RECENT FRACTURES OF THE FEMUR. Henry W. Meyerding, M.D., *Abstract of paper read in Symposium on Fractures at Minnesota State Medical Association*, Oct. 12, 1923.

Dr. Meyerding, in his paper on Non-operative Treatment of Recent Fractures of the Femur, demonstrates the rather unusual types of fractures seen at the Mayo Clinic and the comparative rarity of recent lesions.

Seventy-five per cent of the fractures coming to the Mayo Clinic present non-union, delayed union, mal-union, chronic osteomyelitis, or joint stiffness following treatment elsewhere. In one thousand cases of old fractures, 221 were non-union of the long bones; 120 ununited fractures of the neck of the femur were examined, 26 of which were operable.

The Whitman treatment, in recent fractures of the hip, was advocated and excellent results were obtained. Meyerding had devised a method of obtaining joint motion after the sixth week by the application of two lateral hinges incorporated in the cast to prevent knee stiffness. No recent fractures of the hip were operated upon. In 222 conservative fractures of the femur, 57 were recent fractures, the remaining 165 presenting non-union, mal-union, et cetera.

Meyerding reviews the effect of age and its relationship to treatment, and notes that at times it is better to treat the patient and to accept the fracture with deformity in order to save the patient. He stresses the value of repeated radiograph and mensuration. He believes that adhesive traction and Buck's extension will continue in use, as well as casts, although the use of adhesive traction combined with Thomas extension splint will gradually supplant them. He outlines the routine used in the Mayo Clinic in the examination and care of the fracture and notes that, with such an accurate record and intelligent treatment, the physician is better able to protect himself and prevent embarrassing complications. He advocates extension treatment of fractures of the trochanter area and shaft and, after reviewing the various methods of obtaining traction, gives us his opinion that the caliper extension is the most efficient, using it in conjunction with the Thomas splint or Sinclair modification of the Thomas splint.

In supra-condylar lower femoral fractures, he applies the caliper anterior to the axis of the femur and uses traction in conjunction with Sinclair modification of the Thomas splint, the knee being flexed. He believes that intra-articular fractures, unless practical anatomical re-position is secured, result in permanent partial disability, and operative interference is justifiable.

Five case histories to demonstrate certain points, and illustrations to demonstrate apparatus as used in the Mayo Clinic, are given. One of the principal features is the use of the Balkan frame in conjunction with the Bradford frame, the latter being elevated by the use of windlass to facilitate nursing, et cetera.

CONCLUSION.

We find the Whitman treatment of recent fractures of the head and neck efficient, and open operation unnecessary.

In recent fractures of the shaft, the non-operative treatment has given more satisfactory results, though a comparison of these with those operated upon is unjust, as only the more difficult cases had open reduction. Anesthesia, manipulation, and retention by extension and Thomas splints has been the method of choice in simple fractures. Of 29 simple, 27 were satisfactory—treated conservatively 93.1%.

Fractures in the lower shaft, supra-condylar or condylar, obtain excellent results by flexion of the knee and extension. When Steinmann pin or ice tongs are used, they should be accurately placed anterior to the axis of the femur.

Unless anatomical re-position is obtained in the intra-articular fractures by

conservative treatment, arthrotomy and fixation is indicated, which is accomplished by the use of beef-bone screws.

Unless conservative treatment fails to provide satisfactory reduction, open operation is seldom indicated and then only when proper operating facilities are available.

THE ETIOLOGY OF STIEDA'S FRACTURE. M. P. Schueller and S. Weil. *Beitr. z. klin. Chir.* Vol. 129, No. 1, p. 71.

Contrary to the opinion of Stieda that the bone shadow named by him and found on the inner condyle of the femur is a bone chip torn off the median condyle, hence a fracture, the authors advance and prove their theory that it is merely a new bone formation within the tendon of the adductor magnus *i.e.*, an ossification of tendon fibers which have been injured by an uncoordinated contraction of the muscle in question.

The mechanism of production of this shadow has up to now been explained on two possibilities: 1. direct contusion of the region where the shadow develops in about 3 weeks, 2. distortion of the joint. On the basis of previously published cases and personal observations, the latter possibility can be ruled out. The direct injury to the inner condyle plays but a minor rôle, while the indirect injury, namely a forcible uncoordinated contraction of the M. Adductor Magnus, can in all cases be demonstrated or elicited by the history of the trauma. Provided there was no direct injury to the insertion of the adductor, the indirect trauma mentioned will constantly be the mode of production of this disease. This muscle contraction is a reflex act when the knee joint is about to sustain an injury and the patient is forced to guard the body from falling down.

Just as such uncoordinated contractions of powerful muscles are liable to produce fractures, so does this muscle force tear off or tear out part of its inserted tendon. In this way can be explained why Stieda's bone shadow appears in various injuries to remote regions of the lower extremity, while no direct injury to the knee has occurred. It is possible that there exists about the knee a predisposition to ossification as we notice it in other muscles of this joint.

—*A. Gottlieb, M.D., Los Angeles.*

PATHOLOGICAL CHANGES OCCURRING IN THE SPINAL CORD FOLLOWING FRACTURE DISLOCATION OF THE VERTEBRAE. James E. Thompson. *Annals of Surgery*, Aug., 1923, p. 260.

This is an extremely interesting and thorough description of the pathological changes occurring in accidental and experimental cases. It is an exhaustive study, and the conclusions are as follows:

Regeneration never occurs; active inflammation which occurs during the healing of the gross tissues is never seen. There are never cellular and circulatory changes which are present in tissues undergoing repair. The process consists of oedema, followed by liquefaction and vacuolation.

The advisability of operation is a debated question, some surgeons feeling that

every case should be operated on, in the hope of finding hæmorrhage or deformity, the removal of which will benefit the patient. Others believe it is useless to operate because an injured cord never recovers. The author is strongly opposed to operation as a routine practice, as "it is often unsafe, rarely justifiable and usually futile." He feels that the only positive indication for operation is the persistence of deformity to such a degree as to make it probable that the cord is subjected to pressure.—*Edward S. Hatch, M.D., New Orleans.*

BURSITIS

THE TREATMENT OF CALCIFIED SUBDELTOID (SUBACROMIAL) BURSITIS BY DIATHERMIA. Joseph F. Harris, M. D. *Journal A. M. A.*, July 14, 1923.

Dr. Harris first gives a brief description of the apparatus and of the form and character of electric current used in diathermic therapy. He then reports six cases in detail, which after from five to twenty treatments were cured of all troublesome symptoms and disabilities.

He says that about 80 per cent. recover and that the remaining 20 per cent. suffer no ill effects. He thinks that the failures are due to the nature of the deposit and to the duration of the condition.—*H. A. Pingree, M.D., Portland, Me.*

INFLAMMATION OF THE DEEP CALCANEAL BURSA. Arthur E. Hertzler, M.D., *Journal A. M. A.*, July 7, 1923.

Dr. Hertzler mentions the bursitis as one characterized by an intense pain and tenderness on deep pressure at the inner side of the foot near the sustentaculum tali. Under local anaesthesia he lays bare the bursa and curettes it out and packs for three or four days. He has had twenty or more cases that have remained well for over ten years.

"The bursa lies under the beginning portion of the abductor hallucis muscle, extending laterally to the point of origin of the flexor brevis digitorum. Beneath it lies the sheath of the tibialis posticus muscle."

He discovered the bursa accidentally while dissecting a foot.—*H. A. Pingree, M.D., Portland, Me.*

NEOPLASMS

TUMORS OF TENDON AND TENDON SHEATHS. St. J. D. Buxton. *Brit. Jour. of Surg.*, April, 1923, p. 469.

Tendons: Primary tumors are very rare, and possibly do not occur at all, unless perhaps osteomata.

Tendon Sheaths: A history of trauma is not uncommon; chronic inflammation and irritation are predisposing factors.

Benign tumors include:

1. Lipomata, of which only 18 cases have been recorded. They are not en-

capsulated; hence the sheath must be sacrificed in removing the growth. They occur most commonly in the sheaths of the palm of the hand.

2. Fibromata, as uncommon as lipomata.

3. Chondromata, less common than the other simple tumors. A case is recorded occurring in a professional violinist, and other clinical records are cited.

4. Ganglion. This should be regarded as a tissue degeneration rather than a cystic tumor.

Locally Malignant Tumors:

Giant Celled Myeloma, the commonest of all tumors of tendon sheaths. Such tumors are characterised by small volume, soft consistence, and slow growth. Metastasis does not occur. A case is recorded in a girl, following trauma.

Malignant:

Sarcoma, Rate of growth is rapid when round celled. Amputation of the limb is advised, since dissemination occurs as in other sarcomata.—*Alexander Gibson, M.B., Ch. B., Winnipeg.*

POST-TRAUMATIC BONE TUMORS. S. D. Foster, M.D. *Journal A. M. A.*, Sept. 8, 1923.

Dr. Foster quotes at some length from the reports of many well-known men upon the cause and progress of bone tumors, especially following slight injury.

"There has been a general supposition that repeated slight trauma is the cause of carcinoma, while it is one severe blow that causes sarcoma."

He reports the case of a painter receiving an injury in the lower third of the arm while reaching around the eaves of a building. This produced an abscess which in three months was followed by a benign bony tumor.

Dr. Foster's summary and conclusions follow.

SUMMARY AND CONCLUSIONS.

There has been a general belief among medical men that there is a very definite relation between trauma and bone tumors.

As far as I have searched the literature, there is no experimental proof that injury has caused bone tumors.

Some writers think there is an underlying constitutional factor, which with the trauma, causes bone tumors.

During the war work many cases of bone tumors were reported, following injury, either with or without infection; but most of these war wounds were infected from the onset.

The greatest task in this study is in the line of diagnosis.

In view of the high mortality of sarcoma, especially as to its final results, it would seem advisable to take some extra time to make sure of the diagnosis. It would be better to save a limb in a benign case, even with the slight added danger from the time taken to make this diagnosis as complete as possible.—*H. A. Pingree, M. D., Portland, Me.*

PATHOLOGICAL REMARKS ON SARCOMA OF THE LONG BONES. S. G. Shattock. *Brit. Jour. Surg.*, July, 1923, p. 127.

Nomenclature:

Giant-Celled Tumors of Bone:

The name "giant celled myeloma" is preferred. Some of these tumors are distinctly malignant and produce metastases. Moreover, these giant-celled tumors may originate in soft parts quite independently of bone. Under the term myeloma, the single giant-celled tumor of osteoclasts and the true giant-celled sarcoma have been included.

Endothelioma:

This name should be limited to benign tumors arising from the endothelium of lymph spaces or blood vessels. If malignant, the best name is endothelial sarcoma, much better than plexiform and alveolar sarcoma.

Infection of Lymphatic Glands:

There are two forms of sarcoma, especially adapted to infect lymphatic glands secondarily; the lymphosarcoma and the endothelial sarcoma of bone or elsewhere.

It is not the simple transference of elements that suffice to produce metastatic growth; there is a profound difference in the biology of the simple and the malignant cell.

The Removal of Portions of Sarcoma for Histological Diagnosis:

This practice is widely condemned, and as widely employed. The author has devised an electrically heated borer to remove a cylinder of tissue, coagulating and killing it as the instrument is pressed onwards. Such a borer must be used by penetrating the tumor very slowly.

The Rarity with which the Growth of Sarcoma follows Fracture of the Long Bones.

The author knows of only one case; chondro-sarcoma of the humerus. Like tuberculosis, sarcoma is not set-a-going by fracture; it may be by contusion. The greater injury leads to the greater reaction, and to the local immunisation by cells and body fluids against an extraneous factor.

Pathogenesis of Malignant Disease:

An hypothesis is offered containing three elements:

1. That the agent is a filter passing or ultra microscopic virus.

2. That this is not a parasite but symbiotic, absorbed to the cell-nucleus and cytoplasm—like a dye to filter paper.

3. That for the symbiosis the cell must be prepared. The preparation takes place usually by chronic inflammation. All three factors acting together, the biology of the cell is fundamentally changed.

Interpreted in a concrete form on such an hypothesis, that which is transmitted and constitutional would be the ultra-microscopic virus. The filter passing virus is indifferent or polyvalent; it is the prepared cell that determines the histologic form of the disease. This is congruous with the fact that independent and histologically different carcinomatous tumors may exist in the same subject, or sarcoma may exist with carcinoma. Such symbiosis might be responsible likewise for the abnormal mitosis so conspicuous in the cells of malignant growths.—*Alexander Gibson, M.B., Ch. B., Winnipeg.*

DISEASES OF BONE

OBLITERATION OF BONE CAVITIES IN CHRONIC OSTEOMYELITIS BY FREE FAT TRANSPLANTATION. George R. Dunn. *Minnesota Medicine*, June, 1923.

The author reports the case of a patient forty-nine years of age who sustained a compound fracture of the left tibia in April, 1915, which drained until January, 1922, when a free fat transplant was inserted as a secondary operation following Dakinization. Primary healing was obtained by approximating skin edges, and the wound has remained closed for a period of nine months.

Experiments were carried out in eight dogs, and while no definite conclusions could be drawn, yet it appeared that the fat remained in situ for a considerable time.

The author believes that thorough surgical treatment and Dakinization followed by fat transplantation may be a procedure of practical value in obliterating bone cavities. He briefly reviews the literature on the subject.—*Henry W. Meyerding, M.D., Rochester, Minn.*

OSTEITIS FIBROSA CYSTICA. Dr. A. H. Galvin. *The California State Journal of Medicine*, June, 1923, Page 244.

Osteitis fibrosa cystica shows a predilection for the long bones, especially the femur and the humerus. Its appearance in the flat bones has evidently never been reported. Galvin's case appeared in the angle of the left jaw in a male 23 years old. The patient gave a history of a blow on the left lower jaw 2½ years previous to admission. One year following the injury he developed a swelling and slight soreness; lately the tumor has grown more rapidly. Physical examination was negative, with the exception of a hard tumor mass 5 cm. x 3½ cm. in the region of the angle of the left jaw. Roentgenograms showed a cystic formation in the bone, and also showed an ineverted third molar.

At the time of operation the cortex of the bone was very thin and easily broken into. The cavity was filled with a brown, serous fluid. All the cystic formation was broken down and a transplant from the tibia was inserted. Two months later the removal of a third molar relieved tenderness and bleeding in this area. Patient now has full motion and a firm cortex over the original site of the tumor. The last radiogram showed absorption of the transplant.—*Paul M. Jepson, M.D., Rochester, Minn.*

CAUSE OF KOEHLER'S DISEASE ON THE METATARSO-PHALANGEAL JOINTS. Max Kappis. *Beitraege z. klin. Chir.* vol. 129, no. 1, p. 61.

While the clinical picture of Koehler's disease of the metatarsophalangeal joint has definitely been established, the pathologic-anatomical explanation has not yet been fully explained. The reason for this is that most cases are symptomatically cured by conservative measures and that the macroscopical and microscopical findings are incomplete and allow no connecting deductions. The microscopical findings heretofore reported by Fromme, Axhausen and the author lead to the conclusion that a fracture may have been the primary factor upon

which have developed the pathological details described by the various investigators, i.e., callus like structure with fibrillar and osteoid tissue, degeneration of cartilage, necrotic area of bone which Axhausen ascribes to a primary embolus, and so forth.

Although trauma is not always elicited in the history of the case, it can be established after careful questioning in most patients. That trauma causing fracture should be regarded as the most plausible factor in the etiology, results from the various cases reported and clinically and macroscopically demonstrated at operations and from the two cases of the author, who added to the clinical pictures the histopathological findings which substantiate the opinion that the primary lesion was a fracture of the head of the metetarsal bone, second or third in a few cases. With the suspicion of fracture in view these cases should be more carefully studied to arrive at the final conclusion.—*A. Gottlieb, M.D., Los Angeles.*

OSTEITIS FIBROSA. R. Lawford Knaggs. *Brit. Jour. Surg.*, April, 1923, p. 487.

Osteitis fibrosa is the name given to a disease of bone in which part of the osseous framework and its contained marrow is replaced by fibrous tissue.

Allied conditions of inflammatory origin are seen, e.g., in the vicinity of osteo-arthritic joints as shown by Lane, Zeigler, and Strangeways, or in more definite relation to septic infection, as in a case associated with septic teeth.

As a primary affection, the precise nature of the changes is not so evident. Following Bloodgood, the author classifies bone cysts in the following manner.

1. Single cysts in which there is no connective tissue lining its cavity.
2. Cysts with definite connective tissue lining which can be peeled off from the bony shell.
3. A small cyst or cysts in a solid mass of fibrous tissue.
4. No cysts but the bone shell filled with a solid mass of fibrous tissue.
5. Multilocular cysts. The distended shell of the bone is partitioned into cavities containing either fluid or fibrous tissue.

Clinically, however, the cases fall into the following groups:

1. Those in which the lesion is represented by a uniform mass of fibrous tissue. Examples of this are seen in the tibia of a child aged 5, the femur of a man aged 20, and the femur of a girl aged 18.

2. Cases in which a solid fibrous mass shows a tendency to degenerate and form cysts.

Examples of this are seen in the tibia of a man aged 24, the femur of a woman aged 66, and the femur from a female aged 17.

As a rule, in groups 1 and 2, the production of ossific material is not sufficient to produce a striking change in the naked eye appearance of the fibrous material, though it is often sufficient to cause a feeling of grittiness when the flat side of a knife is drawn over it.

3. Cases in which much bone is developed and the disease shows signs of coming to an end.

The tibia of a woman aged 37, the femur, tibia, and fibula of a man aged 53, and the tibia of a woman aged 65.

4. Single cysts of bone. Is there justification for believing that these cysts originate in pre-existing areas of fibrous osteitis? Such an origin may be inferred when a cyst and a separate fibrous mass occur in the same bone, or when a cyst occurs as part of the generalized disease, or when small patches of fibrous tissue are found in the immediate vicinity of the cyst. The majority of such cases occur in the upper end of the humerus, femur, and tibia. These cysts contain a serous fluid which may be yellow and clear, or chocolate-colored from old hæmorrhage, and in some cases cholesterin crystals are present.

Histology:

The picture is fairly constant.

1. The ordinary bone-marrow is replaced by a dense vascular connective tissue.

2. All the fat disappears.

3. The osseous framework has given place to this connective-tissue.

4. Throughout the connective-tissue replacement, numerous scattered foci of new bone are forming. Eventually they develop into sclerosed masses of bone markedly fibrous in character.

5. The origin of the cysts is not very clearly traceable. They may come from minute areas of liquefactive degeneration which coalesce to form a larger cyst.

6. There is a marked absence of the small-celled infiltration met with in the more acute forms of inflammation.

The Clinical Aspect:

Three types may be distinguished.

1. A limited local deposit, frequently becoming a cyst.

2. A more diffuse affection of a single bone involving the whole or a considerable part of the diaphysis.

3. A generalised form in which many bones are affected.

The patient comes under observation only when the disease is pronounced and for one of the following conditions.

1. Enlargement of the bone.

2. Deformity due to bending.

3. Fracture, complete or incomplete, often spontaneous.

4. Limp caused by shortening.

Occasional complications are giant-celled myeloma and malignant disease, as might be expected with an abnormal tissue in a state of ill-regulated activity.

The Pathogenesis:

How is the bone removed? Probably in one of two ways:

(a) Removal of necrotic trabeculae by giant cells.

(b) Fragmentation and disappearance of osteoid tissue without giant-cells.

Why is the bone removed? Most probably because of some impairment of its vitality to such an extent as to cause its death or render it incapable of recovery.

How can such a change in the bone's vitality be caused? Probably by toxins carried by the blood-stream, and originating from:

(a) Micro-organisms.

(b) Tissue-metabolism.

(c) Intestinal sources.

It must also be recognized that a fourth factor, viz., tissue-resistance to toxic influence, comes into play. The bone-trabaculae composed of a calcified matrix with only a few cells are more vulnerable than the marrow. Reaction may be excited in the marrow, providing a vascular connective-tissue—osteogenic in nature. Finally the new bone becomes dense and sclerosed and the remaining connective-tissue reverts to adipose medulla.

Treatment:

1. Remove any septic focus.

2. Diet opens up a wide field for observation and experiment. Tubby records the case of a medical man who suffered from osteitis deformans, and whose malady seemed to be associated with deficiency of protein and excess of starch.

3. General hygienic measures are, of course, indicated.

4. Surgical.

Removal of a fibrous mass and curettage.

Curettage of a cyst followed by packing or filling.

Excision of the affected segment of bone.

Amputation may be expedient, or in malignant cases necessary.

Osteitis Fibrosa in Goats.

In a number of goats kept under domestic conditions the mandible was attacked by symmetrical swellings which gradually increased until the mouth could not be closed and death resulted from starvation. In some specimens numerous small cysts were scattered throughout the mass. Histologically it is impossible to distinguish the mass from a section of fibrous osteitis in which the new bone formation is of an osteoid character. There can be no doubt that the bone condition is osteitis fibrosa and there is nothing to show that it has any connection with rickets. In the early stages the disease may be associated with an affection of the joints. It is not clear how this peculiarity of the goat's disease is to be interpreted.—*Alexander Gibson, M.B., Ch. B., Winnipeg.*

SUPPURATIVE OSTEOMYELITIS OF THE LEFT SIDE OF THE PELVIS. Irwin P. Levi. *Am. Jour. Roentgenology.* March, 1923, p. 208.

The case presents the following points of interest:

1. Its rarity.

2. The occurrence of the symptoms of peritoneal involvement, due probably to the leakage of the products of infection through the thin peritoneal lining of the abdominal cavity and giving rise to the symptoms of a general peritonitis. This demonstrates clearly that in a case presenting the symptoms suggestive of a general peritonitis, without the history of a disease that would of itself indicate a lesion, such as typhoid fever, pelvic infection etc., occurring in a child the possibility of a pelvic osteomyelitis should not be disregarded and a roentgenologic examination should be made of the entire pelvis to determine the possibility of infection. The symptoms of general peritonitis were the prominent ones in the early stages of the disease.

3. The occurrence of so extensive a process without any history of injury even of a trivial character, or without any other localizing symptom save a

disinclination to use the left leg, and yet at the same time possessing no symptoms which would localize the process to the left hip joint or to the limb of the side of the pelvis involved.

4. The necessity of routine X-Ray examination in all cases presenting symptoms suggestive of pyemia, or of hidden infection, and yet possessing no localizing symptoms, or faint ones at best. By this means and by this aid, many infections whose origin is apparently a mystery can be definitely localized and adequately and properly treated to prevent possible death, or at least limit subsequent deformity.

An illustration shows evidence of a marked suppurative process involving the entire left side. The left side of the sacrum at, and in close proximity to, the sacro-iliac synchondrosis is involved.—*Thomas Madden Foley, M.D., Washington, D.C.*

PATHOLOGIC EFFECTS OF LACK OF VITAMIN A AND OF ANTIRACHITIC VITAMIN. E. V. McCollum, Ph. D. *Journal A. M. A.*, Sept. 15, 1923.

Dr. McCollum points out that rats fed upon a diet containing a well balanced proportion of calcium and a phosphate do well, but that, if either one is much increased or decreased, rickets will develop. The addition of cod-liver oil, butter fat, or cocoanut oil will cure the condition, the beneficial power of the fats, decreasing in the order named, whichever is used. The removal of vitamin A from the fats by oxidization at 212° F. with air bubbles does not seem to lessen the healing power when the fat is added to a diet containing an unbalanced proportion of calcium and of phosphorus in the form of a phosphate.—*H. A. Pingree, M.D., Portland, Me.*

SYPHILIS IN ORTHOPAEDIC SURGERY. Archer O'Reilly, M.D. *The Journal of the Missouri State Medical Association*, May, 1923.

O'Reilly draws attention to the fact that the physical signs and symptoms of bone and joint syphilis are indefinite and contradictory and therefore the diagnosis is by no means easy.

The statement is made that between ten and twenty-five per cent. of the orthopaedic cases are syphilitic and one cannot help but feel that this is probably quite a high estimate. Naturally the incidence of syphilis in orthopaedic practice will vary with the type of case coming to the clinic. The subjective symptoms are not to be relied upon, as many patients are sincere in their denial of syphilis, but a history of soft chancre, gonorrhea, or even a simple abrasion or cut is suspicious and should put the clinician on his guard.

Congenital syphilis diagnoses more readily in the physical signs than in the acquired type. Periostitis is almost always present and involves a number of bones, but osteitis is frequently present. In pure joint syphilis the radiogram will not show any typical signs, but the examination of the bones may clarify the picture by showing typical periostitis.

A negative Wassermann does not exclude syphilis, especially in a congenital type. In questionable cases in children a Wassermann should be made on one or both parents. A positive Wassermann points strongly to syphilis, but it must be remembered that the bone may have two diseases, i.e., tuberculosis or syphilis.

In doubtful cases a therapeutic test should be carried out.—*Melvin S. Henderson, M.D., Rochester, Minn.*

TREATMENT OF ORTHOPAEDIC CONDITIONS

ANKYLOSIS AS THE TRUE CURE OF DESTRUCTIVE JOINT TUBERCULOSIS. E. G. Brackett. *Southern Med. Jour.*, Sept. 1923, p. 697.

The treatment of the early and late stages of joint tuberculosis is very carefully gone into. Each of the methods so well known and used has its place, and it is more a question as the time it is best to apply either method than which method is necessarily best. Certainly traction is to be used in the early and acute cases. In other cases fixation is indicated, and by this means we can supply the necessary protection; always keeping in mind that the ultimate result is the early arrest of the disease. When this point is reached the aim of the treatment becomes different. To quote:

"In the one, the aim is to obtain a joint which retains the structures which are essential to freedom of motion, such as unimpaired cartilage, normal contour of the joint lines, elastic capsule, etc.; in the other, in which these structures have been destroyed, and in which a joint allowing normal function no longer can be expected, the object must be to obtain as a permanent result a limb that will stand stress, and this result at the earliest possible date that is compatible with good treatment. In other words, we should not in this later period of the disease treat symptoms alone."

Long ankylosis is the only absolute and safe cure of a tuberculous disease which has passed into the destructive stage. We should not be satisfied with meeting the present conditions, but rather have in mind the after life of the individual.

The indications for operating to help nature produce an ankylosis as in caries of the spine are taken up, as is also the question of arthrodesis.

Your reviewer believes this to be an extremely important paper and one that is well worth reading in full.—*Edward S. Hatch, M.D., New Orleans.*

HELIOTHERAPY IN INFECTIOUS DISEASES OF THE BONES AND JOINTS. Emil S. Geist, M.D. *Minnesota Medicine*, April, 1923.

To Rollier belongs the credit of having first used the sun clinically on a large scale as a therapeutic agent.

Minnesota is not the most ideal climate for carrying out heliotherapy. Exposure of the entire body surface to the rays of the sun is desirable but is often impossible. Local exposure is beneficial. For the winter months the mercury

quartz lamp probably comes as near simulating a substitute for the sun's rays as any mechanical device so far known. One must be careful not to rush matters too much in the beginning of the application of the sun treatment. The object is to achieve a tan but not a burn. Exposure should be gradual and increased a little each day. Care should be taken to protect the head and eyes. No exposure should take place soon after meals. A distinct rise of temperature is usually a sign that exposure has been too long.

Tuberculosis of the bones and joints presents the largest field for the use of heliotherapy. It increases the appetite and the patients gain in weight. Within a few weeks there is freedom from pain and a general feeling of well being. Fistulae usually close and deformities in the young have a tendency to become less.

Osteomyelitis cases are treated first surgically, then exposed to the sunlight. In chronic arthritis, heliotherapy is of great value in a number of cases. All possible foci of infection must, of course, be removed. In gonorrheal arthritis heliotherapy may be used to advantage after the acute stage. Heliotherapy is of value in rickets as an adjunct to the usual anti-rachitic treatment. In flu infections such as swollen joints, painful feet, and so forth, heliotherapy is of value. Circulatory disturbance of the feet may be improved by the use of the sun treatment.—*Paul N. Jepson, M.D., Rochester, Minn.*

LENGTHENING OF THE TENDO ACHILLIS. H. H. Greenwood. *Brit. Jour. Surg.*, April, 1923, p. 483.

Simple transverse section of the tendon is falling into deserved disfavor. Subcutaneous hemisection of the tendon, done subcutaneously, does not usually produce the desired results, snapping of one of the limbs of the incised tendon or wide separation of the ends usually taking place, as the author has observed on a number of occasions. Open lengthening of the tendon is strongly urged.

Assuming a hinge movement around a coronal axis passing through the centre of the medial malleolus, it is easy to work out the lengthening required to move the foot through any given angle. The elongation required varies from 1 inch in mild equinus cases in infants to 3⅜ inches in severer adult cases.

Since adopting this more exact technique the writer's results have been improved.—*Alexander Gibson, M.B., Ch. B., Winnipeg.*

THE TREATMENT OF CLUB-FOOT, CONGENITAL AND ACQUIRED. Emil S. Geist. *The Journal-Lancet*, April, 1923.

The author makes a study of 127 cases of pes equinovarus, of which 91 were congenital and 32 acquired. The majority of these cases were treated during the first year. 45 cases were bilateral, and 46 cases were unilateral, of which one half occurred in the right foot, and the other half in the left. Etiology, unknown. Pathology consists of shortening of the tendo Achilles, inversion of the foot, and usually a large bursa over the outer portion of the foot; shortening of the flexor muscles and the plantar fascia. The peronei and extensor muscles

are stretched and the foot is usually retarded in growth. The chief symptoms are apparent deformity, chronic back strain and easy tiring. Treatment should be begun immediately after birth.

The author's cases are divided into:

1. The new-born.
2. Those that have walked from one to eight or ten years.
3. Those older than eight or ten years.

In the new-born, treatment is most satisfactory, and is accomplished by successive plaster of Paris casts put on about every two or three weeks, making a slight correction at each operation. In early cases the varus deformity must be treated first. This usually takes from six to eight months.

Following this, tenotomies can be done to correct the equinus deformity, this being preceded by manipulation of the foot. The foot is then placed in a plaster of Paris cast in a markedly over-corrected position. Two or three changes of the casts are then necessary, followed by the wearing of a shoe raised on the outer border, and occasionally a brace may be used. In patients who have walked from one to eight or ten years, the bones have not yet become distorted and much the same procedure can be taken as in the above named group. In patients older than eight or ten years, one must work upon the bony structure of the foot, besides lengthening the shortened tendons. The operation of choice lies between a wedge osteotomy on the outer side of the foot, or an astragalectomy. The author prefers the wedge operation. The younger the patient is seen and the treatment begun, the better will be the result. In some cases the foot persists in "toeing in," and for this a transverse osteotomy of the tibia is done with good results.

ACQUIRED CLUB FOOT.

The majority of the author's cases followed infantile paralysis. The pathology consisted mainly of the paralysis of the everto- and dorsi-flexors of the ankle and foot. The supinators and plantar flexors contract. Treatment consists at first of prevention by means of a brace. If the case is old and comes with an established deformity, tendon transplantation is the operation of choice. This is done by wrenching of the club foot into an over-corrected position, then doing the necessary tenotomies, and putting the foot up in a plaster in an over-corrected position. It is best to wait four or five weeks for the result of the necessary trauma to disappear, after which time the tendon of the tibialis anticus muscle is cut at its insertion and given a new insertion at the base of the fourth and fifth metatarsal. A cast is then applied with the foot in an over-corrected position. The cast is removed in six or eight weeks, after which a brace is applied for about a year.—*Paul N. Jepson, M.D., Rochester, Minn.*

THE AFTER-CARE OF POLIOMYELITIS IN VERMONT. Robert W. Lovett, M.D. *Journal A. M. A.*, Sept. 15, 1923.

Dr. Lovett describes in a brief and very interesting way the examination and treatment of nearly 300 cases of poliomyelitis in Vermont, following the epi-

demic in 1910 to 1913. The work was done by the Health Department of Vermont. First clinics were held by Dr. Lovett. This was followed by the employment of a nurse who visited various centers, held clinics, made inspections, discovered new cases, educated the parents, and made records, in so far as the weather and traveling conditions would permit. When operative procedures became necessary, a small hospital was provided in Boston, and later another one in Proctor, Vt. Finally a common school and vocational department were added at Proctor.

Since 1922 the work has been in full swing with an increased number of full-time help on the spot and an increased number of patients. Dr. Lovett and Dr. Ober go to Vermont as occasion requires for consultations and advisory meetings. Like the work of Dr. Grenfell, the after-care of this epidemic seems like a job well done.—*H. A. Pingree, M.D., Portland, Me.*

ORTHOPEDIC SURGERY OF THE UPPER EXTREMITY. A. Steindler, M.D. *Minnesota Medicine*, July, 1923.

The author states that for the past seven years he has paid special attention to the disabilities of the upper extremity. In discussing these disabilities he considers them from a regional point of view. He discusses the positions of greatest disability and function in the hand as well as motion in the shoulder and wrist and the principle motions thereof. He resorts to surgery only after conservative methods fail and such conditions as ankylosis exist.

In the disability of the shoulder he brings out a sharp line of the differentiation between the intra-articular and extra-articular lesions; the former he believes are seldom benefited by manipulations except for change of position. The extra-articular lesions gain in motion following manipulations. When the contracture of birth palsy does not yield to stretching, he performs the operation of Sever and has had good results in five cases. Where a deposition of lime salts in the supraspinatus tendon occurs, he advises operation, and has performed the operation in seven cases.

He discusses flail shoulder and states that in 85 per cent. of infantile paralysis cases involving the upper extremity, the deltoid muscle is involved. He advocates arthrodesis of the shoulder joint and applies a cast at a right angle abduction and slight forward flexion in children, and 70 degrees of abduction and slight forward flexion in adults. 28 cases were operated upon; 17 showed good results; 5 fair, and 1 poor, and in five the results were undetermined.

In the elbow he has had twelve cases of ankylosis, of which seven gave good results; that is, seventy degrees of motion or more was obtained. Two had forty to seventy degrees and three had less than forty degrees of motion.

In flail elbow he finds frequently the flexors of the fingers and wrist are available and transfers the origins of these muscles so as to cause flexion of the elbow. He used this operation in twenty-one cases, with good results in seventeen. This operation transfers the origin of the flexor carpi radialis, palmaris longus and flexor carpi ulnaris from the internal epicondyle of the humerus,

together with the superficial head of the pronator radii teres, into the intermuscular septum of the humerus.

In the forearm Volkmann's contracture or spastic paralysis is a frequent cause of disability, and when conservative measures—splinting, massaging, and extension fail—surgical procedure is resorted to, the pronator radii teres resected, and the pronator quadratus divided. Supination splints are applied following operation. Eight cases were operated upon in this manner and the contractures released; that is, the contracture was released but pronation was obtained only by rotation of the shoulder afterward.

In flexion contracture of the wrist, the method of Robert Jones, or graduat extension, is advised and, when this fails, operation and lengthening of the flexor tendon is indicated. Twenty-six of these patients were operated upon, and in all the desired correction was obtained.

In paralytic drop wrist, it is important to correct deformity and maintain stability of the wrist, as stability of the wrist assures good function. Steindler believes tendon transplantation is indicated only when it can furnish not only active extension but stability in active extension as well. Twelve tendon transplantations were carried out, four of which were done for infantile paralysis. None of these gave satisfactory results. The results in traumatic paralysis were better than those in poliomyelitic cases. In these cases the flexor carpi radialis was carried around the outer border of the radius to the extensors of the finger, and the flexor carpi ulnaris led to the dorsal surface through the interosseous space. He believes, however, that the question of drop wrist is solved by arthrodesis in the greater number of cases. In combination with arthrodesis the transference of the flexors of the wrist to the extensors of the fingers, he thinks, gives better results.

Arthrodesis of the wrist he performs through a dorsal incision, between the extensor pollicis longus and the extensor indicis proprius; through this incision he removes a wedge of bone from the lower radius and part of the scaphoid and semilunar bones. He applies a cast for two or three months, later a splint, if necessary. Thirty-five of such operations were performed, and the desired correction and stability were secured.

In paralysis of the thumb, with adduction and inability to oppose the thumb to the fingers, he splits the long flexor of the thumb and carries the outer half outward and backward to the base of the phalanx of the thumb. In this way the muscle is made to act as both a flexor and opponent at the same time. Thirteen of such cases were performed in poliomyelitic and peripheral paralysis, with good results in all but two cases. In spastic paralysis with the thumb drawn down into the palm, he transplanted the extensor indicis proprius into the long extensor of the thumb in order to create a check to flexion. He performed this operation fifteen times but does not state the results.

In the cicatricial contractures he has used the pedicle flap in eight cases and advises absolute hemostasis and care in obtaining satisfactory blood supply to the skin by addition to the arterial blood. Accurate apposition, suturing, and fixation in plaster of Paris is recommended, the flap being left in position for twenty days before pedicle is cut.—*Henry W. Meyerding, M.D., Rochester, Minn.*

MISCELLANEOUS

THE LUMBAR TRANSVERSE PROCESSES. Morris L. Bierman. *Am. Jour. Roentgenology*, June, 1923, p. 456.

In following a routine for gastro-intestinal examinations wherein a preliminary radiogram of the patient was taken in antero-posterior direction of the kidneys, gallbladder, and lumbar spine, there have frequently been observed solutions of continuity of the transverse processes of the lumbar vertebrae, usually unilateral, but at times bilateral.

Three illustrations of radiograms showing anomalous ribs simulating fractures, are presented in the text.

CONCLUSIONS.

1. The transverse processes of the lumbar vertebrae, especially the first lumbar, very frequently show anomalous development.
2. The unilateral lumbar rib is easily differentiated from fracture, unless the rudimentary rib is very short. Then differentiation must be made by the appearance of the bone, the situation of the lesion, and the lack of injury to neighboring parts.
3. Unilateral or bilateral failure of the secondary epiphysis to unite with the transverse process, while probably the least frequent of the two conditions, will, at times, also be difficult to differentiate if found after injury.—*Thomas Madden Foley, M.D., Washington, D. C.*

MYOSITIS OSSIFICANS AND VOLKMANN'S PARALYSIS. W. Rowley Bristow. *Brit. Jour. Surg.*, April, 1923, p. 475.

Two case histories are reported.

1. Traumatic Myositis Ossificans:

Massage and mobilization were commenced after a supra-condylar fracture. Three weeks later, the elbow was hot, inflamed, and tender. After a few days' rest it was possible to resume the flexed position, 5 or 6 days being occupied in doing so. Skiagrams taken at intervals showed new bone formation in the brachialis muscle, and decrease of this under the influence of rest.

2. Volkmann's Contracture:

A boy aged 8 was seen 3 months after a supra-condylar fracture, showing typical picture of ischaemic contracture. There was complete anaesthesia in the median and radial areas, incomplete in the ulnar. X-Ray showed the sharp lower end of the upper fragment of humerus projecting into the antecubital fossa. At operation the median nerve was found to be completely divided. Further treatment consisted in reduction of the deformity by splinting. Pieces

of muscle were removed for microscopic examination. Colored pictures of sections are shown. The pathologist's report was that "the whole process seemed to be one of absorption and replacement of dead muscular tissue by fibrous tissue, the muscle acting as a non-septic, non-irritating foreign body, and being treated as such by the surrounding tissues."

The prognosis would seem to depend mainly upon the severity and extent of the original lesion, and in severe cases must always be bad.—*Alexander Gibson, M.B., Ch. B., Winnipeg.*

THE STATICS OF THE HUMAN ARCH WHEN SUBJECTED TO BODY WEIGHT. Halbert L. Dunn. *Military Surgeon*, June, 1923, p. 568.

An exhaustive study of this subject comprising sixty-one pages, including twelve illustrations, thirty-nine tables, and a summary in forty-two sections.

CONCLUSIONS.

Hypertrophied muscles of the foot are relatively unyielding when subjected to body weight.

Hypertrophied muscles of the foot after a few days of rest become weaker functionally than muscles of the normal foot.

The medial longitudinal arch of the human foot acts mechanically like a true arch in the distribution of additional loads to which it is subjected.

Both the high arch and the low arch can be functionally normal.

The reaction of the arch to static forces depends almost entirely upon the integrity of the ligaments by which it is supported.

The best criteria of normal and abnormal arches are functional tests.—*Thomas Madden Foley M.D., Washington, D. C.*

DROP WRIST—TRAUMATIC AND BILATERAL. Everett Monroe Ellison. *Boston Med. and Surg. Jour.*, Aug. 30, 1923, p. 309.

This paper deals very interestingly and carefully with the causes of drop wrist and the methods used for the relief of this condition. One very interesting case is reported.—*Edward S. Hatch, M.D., New Orleans.*

ROENTGEN GASTROINTESTINAL STUDIES OF PATIENTS WITH CHRONIC DEFORMING ARTHRITIS. R. G. Taylor. *Jour. Roentgenology*, June, 1923, p. 424.

The purpose of this paper is again to call the attention of the roentgenologists to the importance of roentgen studies in these cases, to the value of the findings, and to the very distinct and very easily demonstrated types of lesions that are almost invariably found in the gastrointestinal tract of these patients: also to impress on the internists who are interested in treating the disease with the intestinal infection theory of causation as a basis, the futility of attempting to get permanent results in the cases which show frank surgical lesions.

"In a general way, the things we have observed have been: First: the majority of these patients have a certain type of colon characterized typically by its abnormal length and abnormal mobility. Second: practically all the cases that have become chronic show so-called surgical lesions in the right colon, or in the ileum, or in both. Third: these lesions consist of adventitious bands similar to Jackson's membrane, involving the colon, usually above the ileocecal valve, and involving occasionally the ileum, producing the so called Lane kink and other less typical fixations."—*Thomas Madden Foley, M.D., Washington, D.C.*

PAINFUL SHOULDER. Araho Edward Wilcox, M.D. *Minnesota Medicine*, April, 1923.

This study of the painful shoulder is introduced by a consideration of the anatomy of the shoulder joint. Attention is directed to the wide range of motion in the joint, the attachment of the arm to the body principally by muscles, the importance of an understanding of the muscle balance in treating injured shoulders, the location of the subdeltoid and subscapular bursae, the relationship of the circumflex nerve to the surgical neck of the humerus, and the liability of the nerve to injury.

With these anatomic facts in mind, various painful disabilities of the shoulder are considered. Stress is laid on the importance of an accurate anatomic diagnosis in relation to the treatment indicated. For instance, simple strain of the deltoid should be treated by putting the muscle at rest on an abduction splint, tear of the insertion or tendon of the supraspinatus should be held with the arm in abduction and outward rotation. Mention is made of the importance of looking for and instituting proper treatment for simple traumatic arthritis of the shoulder joint, which so often accompanies a Colles fracture in older persons. Pain in the shoulder due to infective processes (focal infections) often is associated with limited motion due to adhesions. If the joint cartilage has not been destroyed, function can often be restored by passive motion in breaking the adhesions, followed by baking and massage.

Contusions of the shoulder with direct injury to the circumflex nerve are to be treated by putting the paralyzed deltoid at rest with the arm on an aeroplane splint. Attention is called to those painful shoulders without history of injury, with sudden onset of symptoms and with negative X-Ray findings. Later one is apt to find fluctuation in the evidence of destruction of the glenoid.

In the consideration of subdeltoid bursitis, the author speaks of the presence at times of calcareous deposits shown by the roentgenogram. Abduction treatment, together with physiotherapy, is recommended for subdeltoid bursitis with negative roentgenogram, but operative interference is advised in the cases with a positive roentgenogram.

Admission is made that there are types of painful shoulder, especially in unstable, neurotic young women, in which a definite diagnosis cannot be made, and in which treatment seems to be of no avail.—*Hugh T. Jones, M.D., Rochester, Minn.*